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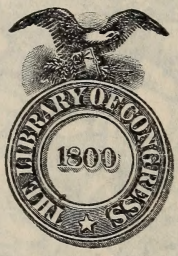

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ROGERS, ROWLAND (*A*).
Picture Service Corp., 74 Sherman St., at Harris Ave., Long Island City, N.Y.

ROSEMAN, ISADORE (*A*).
Kodak A.G., Markgrafenstrasse 7-6, Berlin, Germany.

ROSEN, JOSEPH (*A*).
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ROSENBERGER, HEINZ (*A*).
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PRESIDENTIAL ADDRESS

Spring Meeting of the Society of Motion Picture Engineers, New York, N. Y., May, 1929

L. C. Porter*

LADIES and Gentlemen, both members and guests:

IT gives me great pleasure to welcome you to the Spring Convention of the Society of Motion Picture Engineers. Last Spring we met in Hollywood, the center of the producing end of the industry. It is, therefore, particularly fitting that this meeting is held in New York City where a great deal of the technical design and manufacture of motion pictures is centered and where there is the greatest consumption of the Hollywood films. Thru these two meetings the Society will get a well balanced picture of the present status of the entire motion picture industry, and the industry will have had opportunities to become familiar with the Society and its possibilities.

We have not held a meeting in New York City since 1917. Since then, there has been a steadily growing call for a meeting here, culminating in a recent letter ballot sent to the entire membership, both Active and Associate, which resulted in a two to one vote for New York City over the next choice, Asbury Park.

It has been the policy of the Society for several years to hold alternate meetings in a large city and a more or less secluded place. The advantage of the former being an opportunity to see things, and for the latter, the keeping of those in attendance at the convention, together with an opportunity for fuller papers sessions and closer personal contacts.

In line with the above policy our Papers Committee has arranged that this New York meeting will be largely a tour of inspection. In order to conserve time, most of our papers will be presented at the various places which we are to visit rather than at the hotel.

The papers Committee has prepared a wonderful program. This was done under considerable handicap as the Chairman was on

* Edison Lamp Works, Harrison, N. J.

the West Coast during most of the time usually spent in preparation for a convention. I should like to take this occasion to thank Mr. Coffman and his associates for the work they have done and will continue to do before this program appears in our Transactions. This program again features sound and its latest developments. In the past we have heard of and about television; our present program indicates that we are to have an actual demonstration of this latest marval of engineering science.

Last fall, I outlined some of the policies which I proposed to follow as chief executive. Among those, was that of having the membership in general participate as much as possible in the conduct of the Society. You may have noticed an evidence of the carrying out of that policy by the increased number of committees and the increasing personnel of those committees. We now have 13 committees with a total membership of 125. There are, of course, some cases where the same man holds membership on more than one committee, but this has been avoided as far as practical. The total number of members may be reduced as experience indicates those who take hold and work and those who do not.

These committees were selected by the following method. A circular letter was sent to the entire membership, Active and Associate, asking each man if he would be willing to do committee work, and if so, on which committee he desired to serve. The Board of Governors was asked to recommend the man who they thought was best suited to act as chairman of each committee.

The Committee Chairmen were then appointed. They were then asked to name the men whom they felt would be most useful on their committees. All of these data were carefully reviewed and checked up against the knowledge I had, as to individual characteristics gained thru long and intimate connection with the conduct of the Society and the men's past records of service to the Society.

The personnel of the committees was then selected and appointments made. Obviously, it was not possible to please everybody in every instance. I believe, however, that we have well balanced committees representative of the various interests in the Society, and with a combined knowledge of their particular fields far in excess of that held by any other bodies of men in the world.

The response of the various committees to the work assigned has been splendid. It has been my privilege to sit in on several

committee meetings. I can truthfully state that I have never seen a more sincere, earnest collection of men who are giving freely of their time and ability for Society affairs.

These committees are backed by a Board of Governors that is well balanced as to older, experienced and perhaps conservative men, well versed in the Society's history and policy, and younger men with perhaps more vision, enthusiasm and initiative.

Our committees are working out certain things that will have a far-reaching influence on the future of our Society. The membership committee is particularly active. They have as their ambition 1,000 members by 1930. Such a rapid expansion of our membership however creates new problems that must be, and are being, given most serious consideration. Among these is the question of finance.

Our Business Relations Committee made up largely of executives is doing some excellent work along those lines. This committee, of course, has the closest co-operation of our Treasurer.

I cannot speak too highly of the thorough manner in which Mr. Hubbard is handling the finances of the Society. It is a thankless, detail job. Dunning people for dues, again and again, is anything but pleasant. Collecting for transactions and keeping the books of the Society is a job which we are mighty fortunate in having a man of Mr. Hubbard's ability do for us.

Another problem that expanding membership raises is, the possibility or advisability of replacing our present Transactions with a monthly journal. Our Journal Committee is collecting some excellent data along those lines.

Increasing membership and the rapid expansion of the sound picture has created many new problems for our Standards and Nomenclature Committee. Perhaps few of us realize how much the future success of the industry depends on standardization during the early development period we are now going thru,—you might almost say, on the honeymoon of sound and pictures. Our present Committee has already laid the foundations for some exceptionally good work along those lines.

I have not gone into the details of the work done by those committees, nor even mentioned all of our committees. Each will report to you in detail later on in the convention.

Our ambitious Membership Committee, co-operating with the Reciprocal Relations Committee, has given birth to a new child since our last convention. We now have a healthy London Section of some 60 or so members. Many problems have arisen in connection with this Section. The difference in characteristics of Englishmen and Americans; the time involved in correspondence, etc. have caused some delays. We are fortunate in having the Chairman of the London Section Mr. Rowson with us. As a member of the Board of Governors, he will have an opportunity to discuss with us personally the problems of the London Section, some of which may come up for Society action at a later time in the convention.

Since the last convention we have changed Secretaries. Our new Secretary, Mr. Burnap, took up the work without the advantage of having previously served on the Board of Governors. This, together with the rapid expansion of the Society made his task particularly difficult. In fact the work piled up so fast that it became imperative for him to have an assistant. This is something which we have foreseen for some time. Sally Renwick, a graduate of Colorado Womans College was engaged as Assistant Secretary Treasurer. She has been very busy and is doing excellent work. The new Secretary and his assistant, between them, are getting the mass of detail work into excellent, smooth running order. I think the Society is to be congratulated on having their services, and I know they have some good constructive things planned for the future.

Our Pacific Coast Section continues to hold regular, interesting and successful meetings. We are fortunate in having the chairman of this section, Mr. Dunning, here at the convention. He will probably tell you more in detail of the Section's activities.

In conformity with the policy announced by your chief executive of keeping the membership informed as to the details of the conduct of your Society, I am glad to advise you that your Board of Governors held meetings on December 3, 1928, and March 29, 1929, at which meetings the following essential actions were taken:

(1) The Business Relations Committee was authorized to try out their proposal to sell subscriptions to the Transactions instead of soliciting advertisements in numbers 36 and 37 Transactions. In order to meet the anticipated results of this campaign, 1,600 copies each of No. 36 and 37 Transactions were authorized instead of our usual 600.

(2) The application for the formation of a London Section of the Society was approved and the section authorized.

(3) The secretary was authorized to present a complete unbound set of transactions to both the London and Pacific Coast Sections.

(4) A paid assistant secretary-treasurer was authorized and an appropriation passed to cover the expenses of such an office.

(5) The auditors report of examination of the treasurer's accounts was approved and the Board's appreciation of the treasurer's services expressed to him.

(6) The Secretary was authorized to collect and store films of previous SMPE meetings.

(7) A committee was authorized to investigate the desirability of replacing our present Transactions with a monthly journal and to investigate ways and means of doing this.

(8) Reports from the various committees were discussed and accepted.

(9) The secretary was authorized to distribute a copy of the revised Aims and Accomplishments booklet to libraries in U. S. and Canada.

(10) The chairman of the Publicity Committee was authorized to increase size of the SMPE bulletin in accordance with sample submitted.

(11) The Secretary was authorized to take over the preparation and publication of the bulletin after the 1929 Spring Convention.

(12) The price of Transaction to non-members, starting with No. 37, was increased from $2.50 to $3.00 per copy. The price to SMPE members and libraries to remain at $2.50.

(13) A rule was passed that no Transaction will be sent to delinquents. A delinquent being previously defined as a member whose dues remain unpaid six months after they become due.

(14) A registration fee of $2.00 for members, $1.00 for ladies and a charge of $4.00 for the banquet for members and $5.00 for guests was approved for the Spring Convention. Guest cards of admission to the papers sessions were authorized.

(15) Billing new members on a prorated quarterly basis, starting from the date of Secretary's notification of acceptance of application by the Board of Governors, was approved.

A recent analysis of our membership is very interesting. It shows that our Society is composed of a group of exceptionally capable men who report their positions as follows:

Engineers 129	chief	40
	research	22
	technical	14
	consulting	11
	projection	8
	chemical	6
	installation	6
	physicists	5
	mechanical	5
	electrical	4
	radio	3
	designing	2
	film recording	2

Executives 74	Presidents	25
	Vice-presidents	18
	Secretary and Treasurer	15
	Gen. Managers	16
Managers 56	Managers	22
	Production Managers	15
	Technical	8
	Laboratory superintendents	6
	Experimentors	5
Cinematographers 45	Camera Men	25
	Chief Cinematographers	20
Directors 42	Sales Managers	13
	Editors	9
	Sales Representatives	6
	Advertising Managers	3
	Patent Attorneys	2
	Lawyers	1
Commercial 58	Projectionists	30
	Producers	11
	Owners	10
	Distributers	7
Miscellaneous 14	Manufacturers	5
	Chairman	2
	Inventors	4
	Prof. of Photography	3

The class of men composing our membership is changing. We are acquiring an increasing number of members who are primarily interested in radio and acoustics as applied to sound pictures. We shall have to watch carefully to prevent unnecessary duplication of effort and papers with such organizations as the Institute of Radio Engineers, The Acoustical Society, etc. There must, of course, be close co-operation between our organization and others whose interests bear on, or interlock with ours.

As we grow in size we may soon approach the time when it will be desirable to hold local meetings between the main conventions. I believe several such meetings could to good advantage be held in New York City.

We have a very full program before us. In order to carry it out we shall have to stick pretty close to schedule. Insofar as possible, papers will be presented at the time and on the dates indicated; otherwise, they will be held over to the end of the con-

vention. Let me solicit your prompt attendance at all scheduled events.

In conclusion, I wish to express the most sincere gratitude and appreciation to our Convention Committee, and to all others who have worked long and hard to make this the most outstanding meeting so far in the history of our Society.

ADDRESS OF WELCOME

MAJOR EDWARD BOWES*

MR. CHAIRMAN and Gentlemen of the Convention:

It is a pleasure to have the privilege of saying a few words to you on behalf of the Motion Picture Industry, and a compliment which I appreciate deeply. You have much work before you and will listen to many speeches of deepest interest to you, so I feel that the kindest thing I can do is to be very brief.

The work which you have done, and are doing, has been of enormous value to the Motion Picture Industry in the great progress which has been made. I regret to say that the part which your association has played in this astonishing advance has not been properly credited to you.

There is, however, a growing understanding and appreciation by those who have benefited so largely by your efforts, and I believe that as time goes on, this understanding and appreciation will be more general. I hope so. You deserve it.

With the coming of sound pictures, your work is not only valuable, but I should say indispensable. I feel this sincerely, and I propose to do all in my power to spread the gospel of your accomplishment. The producers and exhibitors should get behind you solidly and support you; and I know they would be happy to do so if they had a closer contact with your Society. I shall try to help in this.

I hope you and your families will have time to avail yourselves of the courtesy of the larger theatres which has been extended to you through Mr. McQuire. Perhaps your families may thus spend a pleasant hour or two while you are busily engaged here.

I would like you to know that my greeting to you, though very brief, is genuinely sincere, and that you may well be proud of the splendid constructive work you are doing.

I thank you.

* Capitol Theatre, New York, N.Y.

REPORT OF STANDARDS AND NOMENCLATURE COMMITTEE

May, 1929

TWO meetings of the committee as a whole have been held since the semi-annual meeting of the Society at Lake Placid. The first of these was held on February 20, 1929, in New York. Those present were: Messrs. Sponable, Spence, Sease, Rayton, MacKenzie, Dreyer, Chanier, Burnap, Brown, and Jones, Chairman. This meeting may be regarded as an organization meeting at which the entire field of the committee's activities was discussed in a general way and an attempt was made to outline the work which it seemed desirable that the committee should undertake. The extent of the field requiring the attention of this committee has become so broad it is practically impossible for one individual to successfully initiate and follow up all the work that should be done. Moreover, the personnel of the Standards Committee at present is very large. It is difficult to get all of the members together frequently and it was felt that small committees of only two or three members each could, in the initial stages at least, deal more efficiently with various problems. The following subdivisions of the field were made and the subcommittees appointed:

1. Sound film practice:
   E. I. Sponable
   H. W. Dreyer
   Donald MacKenzie, *Chairman*

This committee was requested to study the standardization of the dimensional characteristics of positive sound film. This includes width and position of the sound track on the film, the dimensions and position of the picture area, distance between the picture gate and the sound slit, and all other dimensional characteristics relating to positive sound film and its use.

2. 35 mm. film and equipment, including 35 mm. sprocket, projector, and camera practice:
   H. N. Griffin
   A. S. Howell
   G. L. Chanier
   J. L. Spence, Jr.
   V. B. Sease, *Chairman*

The scope of this committee's activities is rather wide, including particularly the sprockets used in handling 35 mm. film in projectors, cameras, and processing machinery. It has come to the attention of the committee that some equipment is now being manufactured which does not conform to the standards officially adopted by this organization. The subcommittee was therefore requested to look into this situation and to attempt to reconcile any differences between our standards and existing practice. If conclusive evidence can be produced indicating that our present standards are unsatisfactory, revision should be made. This subcommittee was charged with the responsibility of attempting to clear this matter up at the earliest date possible.

It was suggested that charts similar to those already adopted for 16 mm. sprockets be prepared for 35 mm. sprockets and that these charts should show standard dimensions for sprockets differing in number of teeth and angle of film contact. This subcommittee was requested to deal with this matter.

The subcommittee was also assigned the subject of standardization of cores on which manufacturers are to supply negative film, as suggested by the Seventh International Congress of Photography. The sample core submitted by the Congress was turned over to the subcommittee for analysis.

Certain other matters, such as the position and size of printer notches on negative, were also assigned to this subcommittee.

3. 16 mm. dimensions and practice:
   A. S. Howell
   A. N. Goldsmith
   L. A. Jones, *Chairman*

While this Society may not be as vitally interested in the substandard films as in the standard 35 mm. film, it seems desirable to give some attention to this field. The standards already adopted seem to be quite satisfactory, but there may be a few minor points requiring attention.

4. Nomenclature:
   A. N. Goldsmith
   F. L. Brown
   W. R. G. Baker
   W. B. Rayton, *Chairman*

In the early years of this Society's life considerable time was spent by the Standards and Nomenclature Committee in defining specialized terms used in the industry. At that time definitions were written and submitted to the Society and officially approved, or, more usually, rejected. This practice excited an enormous amount of discussion and the results achieved do not seem to be of sufficient importance to warrant the continuance of this procedure. There are, however, many words and phrases used with a highly specialized meaning in the motion picture industry, and the committee has had frequent suggestions submitted relative to the establishment of definitions of these terms. After discussing this matter it was the general consensus of the committee that no attempt should be made to write and adopt official definitions. The committee feels, however, that a rather complete glossary of specialized terms used in the industry may be of considerable value. This subcommittee was therefore requested to prepare a list of definitions of this kind.

The second meeting of the committee was held March 25 at which the subcommittees reported progress of work to date. On this occasion the various problems were discussed at considerable length and some definite recommendations made. Many of the points brought up were referred back to the committees with request that the chairman report formally by correspondence as soon as possible.

Following is a summary of the work of the committee up to the present time.

Sound Film Practice

There are so many factors and divergent opinions involved in this subject that it has been very difficult to obtain complete agreement as to a proposal for dimensional standards relative to practice in making sound film positive. There seems to be fair agreement relative to certain points, however, and the following proposal is drawn and presented for your consideration.

For combined sound and picture on 35 mm. film. It is proposed that a space 0.121 inch inward from the inside edge of the perforations on the right facing the emulsion with image inverted shall be set aside as a total space in which to print the sound record. This space provides for a clearance of 0.004 inch between the inside edge of the perforation and the outside edge of the sound track proper,

and a clearance of 0.017 inch between the inside edge of the sound track proper and the edge of the picture, leaving for the sound track proper a space 0.100 inch wide. The center line of this sound track lies at a point 0.243 inch from the edge of the film and 0.054 inch from the inside edge of the perforations. This may be defined as the position of the center line of the sound track space. For variable density recording this space is utilized as shown in Fig. 1.

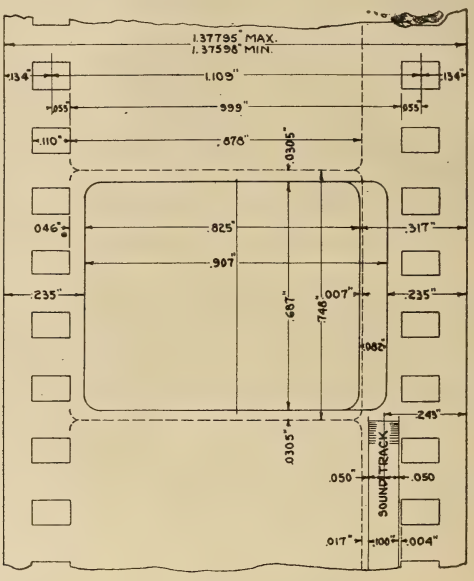

Fig. 1.

This recommendation fixes the position of the center line of the sound track with respect to the edge of the film leaving a certain amount of latitude for the utilization of the available space. It does, however, fix definitely the essential dimensions so that films made according to this standard will fit any projector made to meet this dimension.

It is recommended that the distance between center of picture gate and scanning line shall be 14.5 inches, the latter being below.

In sprocket design the expression "number of teeth in contact with the film" has been used frequently but no definition of this has been given. It is proposed to define this term as follows:

The number of teeth in contact with the film shall be the number of teeth in the arc of contact of the film with the drum, the pulling face of one tooth being at the origin of the arc.

This is illustrated in Fig. 2.

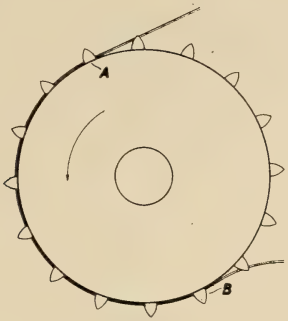

FIG. 2.

35 mm. Film and Equipment

Light change notches on negative film. This question has been discussed at length by the committee but no definite recommendation has been formulated. It does not appear that we can agree

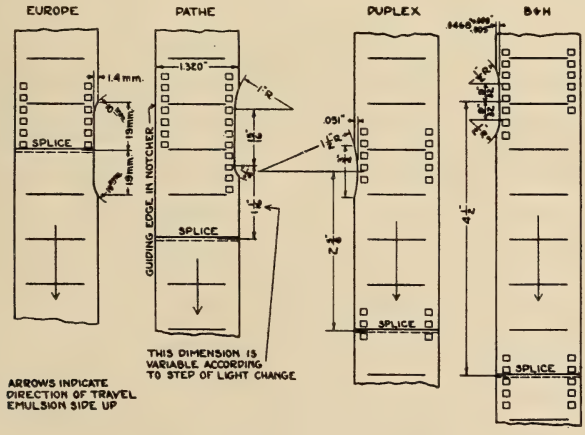

FIG. 3.

to the recommendations made by the International Congress of Photography since the practice in this country is widely divergent from those recommendations. The situation as it exists at the pres-

ent time is shown in Fig. 3 in which the notching practice of Bell and Howell, Duplex, Pathé, and the International Congress recommendation are shown together for the sake of comparison. There are in existence at present large quantities of negative which have been notched by three of these methods. The settlement of this question involves many considerations, not only the existing negative which is already notched, but also printer design, method of light control, etc. The committee feels that it is highly desirable to reach some definite agreement on this subject and a continued effort will be made to find some solution.

Rings for negative raw stock. This matter has been considered from different angles but no definite agreement has been reached. The matter is at the present time under discussion by various film and camera manufacturers. It seems quite probable that some definite agreement can be reached and it is therefore held open for further work.

35 mm. sprockets. An effort has been made to obtain from those manufacturers who are making sprockets not in conformity with our standards, a definite statement of their objections to our standards together with proposals for modification. Thus far, the committee has not been able to obtain this.

16 mm. Dimensions and Practice

Safety film. It seems desirable that the Society formulate a definition of this term. The terms "noninflammable," "slow burning," and "safety" have been used in referring to the film base used in the manufacture of some 35 mm. and all substandard widths of motion picture film. The committee recommends that the term "safety film" be adopted in reference to this material. It does not seem possible to formulate a definition of this material in terms of its chemical constitution since widely different materials and combinations may be used for its manfacture. It does seem possible, however, to define the degree of inflammability in a way which should be very satisfactory as a practical test for differentiating between safety and non safety supports. The following definition is proposed:

The term "safety film" may be applied to any material, either uncoated support, support coated with emulsion, or the exposed and processed product, which has a *burning time* greater than fifteen

(15) seconds; the burning time being determined with a sample of standard size and according to the procedure of the Underwriter's Laboratories.

Dimension of Test Sample

Length: 36 inches, 914.4 mm.
Thickness: 0.005 to 0.006 inch, 0.122 to 0.152 mm.
Width: 0.630 to 1.378 inches, 16 to 35 mm.

This definition was formulated after a consideration of the data on burning time of various samples of film base and newsprint paper shown in Tables I, II, III, IV, and V. These data were obtained by using samples from various sources, both domestic and foreign, and represent fairly well the materials now commercially available. The tests were run according to the procedure of the Underwriter's Laboratories, as follows:

> "Strips of the product and ordinary newsprint 1″ wide and 10″ long, and 1″ wide and 36″ long, were suspended vertically by a small wire through a pin hole at one end of the strips. A gas test flame ¾″ long and ¼″ in diameter was applied at the lower end of the suspended strips. The relative ease of ignition, height of flame and time required for complete combustion were observed."

The tests were made in a place protected as far as possible from drafts, although no hoods or shields were used.

The column designations are as follows:

L—length of test sample (inches)
T—thickness of test sample (thousandths of inches)
W—width of test sample (mm.)
T_i—time of ignition (seconds)
L_f—length of flame (inches)
T_c—combustion time (seconds)

No statement has been made as to the temperature and relative humidity of the samples or the atmosphere in which the tests should be made. This factor will have relatively little effect on the test of film base. It is quite possible that the relative humidity of the newsprint sample will affect the burning time. The tests quoted in Table III were made at room temperature (70°F) and the samples were in equilibrium with an atmosphere of approximately 40 per cent relative humidity.

TABLE I

Safety Film Base (uncoated)

Test No.	*L*	*T*	*W*	T_i	L_f	T_c
1	36″	5.25	25.4	1	3	60
2	"	"		1 to 2	6	43
3	"	"	"	1	5	53
4	"	"	"	1	4	90
5	"	"	"	2	5	70
6	"	"	"	1	3	60
7	"	"	"	1.5	4	64
8	"	"	"	1	5	20
9	"	"	"	1	8	30

TABLE II

Safety Film Base (emulsion coated)

10	36″	6.0	25.4	4	7	40
11	"	"	"	3	9	67
12	"	"	16.0	3	4	68
13	"	5.25	"	2	4	46

TABLE III

Safety Film Base (coated, flashed, processed)

14	36	6.0	25.4	2.	12	26
15	"	"	"	1.5	12	44
16	"	"	16.0	3.	6	58
17	"	5.25	"	2	3	64

TABLE IV

Newsprint Samples

Test No.	*L*	*T*	*W*	T_i	L_f	T_c
18	36″	2.5	25.4	$\surd 1$	18	14
19	"	"	"	$\surd 1$	24	12
20	"	"	"	0+	18	11
21	"	3.0	"	0+	20	10

TABLE V

Nitrate Film (coated)

22	36″	5.75	25.4	0	30	4
23	"	6.0	"	0	"	3
24	"	6.0	16.0	0	"	3
25*	"	5.75	25.4	0	"	4
26*	"	6.0	25.4	0	"	3
27*	"	6.0	16.0	0	"	3

* Flashed and processed.

The definition as stated, therefore, in effect, defines "safety film" as any material having a burning time greater than ordinary newsprint.

Nomenclature

The subcommittee on nomenclature has been very active and has prepared an excellent and comprehensive list of terms with definitions. It is not proposed to submit this to the Society for official approval. Having received the careful consideration and approval of this committee, it is proposed to publish the list in the Transactions as a part of the committee report and it is hoped that it will be found useful and not excite too much criticism.

The items which the committee wishes to present now for initial acceptance by the Socitey are:

1. Taking speed.
   Standard taking speed shall be 24 pictures per second.
2. Projection speed.
   Standard projection speed shall be 24 pictures per second.
3. The scanning slit (for combined sound and pictures on 35 mm. film) shall be located 14.5 inches below the picture gate.
4. Location and width of the sound track on combined sound and picture positives.

   The location and dimensions of the sound track area as recommended by the committee for standardization is shown in Fig. 4. These dimensions are identical with those applying to the same distances in Fig. 1 In Fig. 4, however, only those dimensions pertinent to this particular item of standardization are given. If the Society sees fit to adopt these dimensions as a standard Fig. 4 will then be placed and incorporated in the body of our standards as a chart similar to those already adopted showing film and sprocket dimensions.
5. Number of teeth in contact with the film shall be the number of teeth in the arc of contact of the film with the drum of the sprocket, the pulling face of one tooth being at the origin of the arc.
6. The term *Safety film* may be applied to any material, either uncoated support, support coated with emulsion, or the exposed and processed product, which has a burning

time greater than fifteen (15) seconds; the burning time being defined as the total time (in seconds) required for the combustion (of a sample of standard dimensions) as determined according to the procedure of the Underwriter's Laboratories. Size of standard sample for determination of burning time:

Length—36 inches, 914.4 mm.

Thickness—0.005 to 0.006 inch, 0.122 to 0.152 mm.

Width—0.63 to 1.378 inches, 16 to 35 mm.

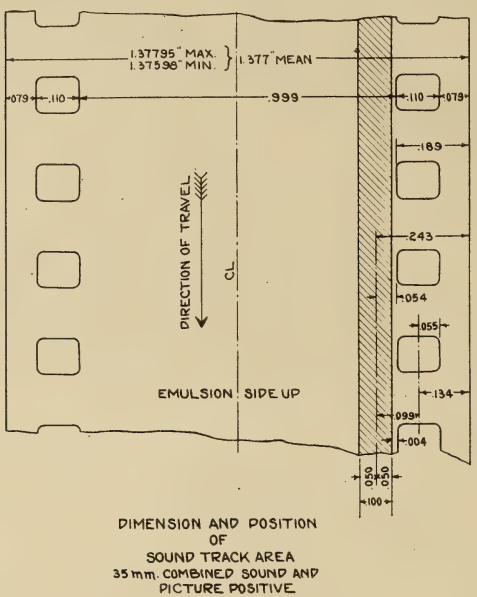

FIG. 4.

Summary of Action taken on the report of the Standards and Nomenclature Committee

The following items as proposed by the Standards and Nomenclature Committee and modified during the discussion of the report received the initial approval of the Society. These must now stand for six months, after which they will again be presented to the Society for final adoption.

1. Taking speed for standard 35 mm. sound pictures shall be 24 pictures per second.

2. Projection speed for standard 35 mm. sound pictures shall be 24 pictures per second.
3. The scanning line shall be located 14.5 inches below the picture gate.
4. Location and width of sound track for combined picture and sound positives. The dimensions and position of a sound track area shall be as shown in Fig. 4, that is on the left side of the picture.
5. The number of teeth in mesh with the film (commonly referred to as "teeth in contact") shall be the number of teeth in the arc of contact of the film with the drum of the sprocket, the pulling face of one tooth being at the origin of the arc. (see fig. 2).
6. The term *Safety film* may be applied to any material, either uncoated support, support coated with emulsion, or the exposed and processed product, which has a burning time greater than fifteen (15) seconds; the burning time being defined as the total time (in seconds) required for the combustion (of a sample of standard dimensions) as determined according to the procedure of the Underwriter's Laboratories. Size of standard sample for determination of burning time:

   Length—36 inches, 914.4 mm.
   Thickness—0.005 to 0.006 inch, 0.122 to 0.152 mm.
   Width—0.63 to 1.378 inches, 16 to 35 mm.

DISCUSSION

PRES. PORTER: Standardization is one of the major reasons for the existence of our society. I cannot emphasize too strongly the importance of it, and I feel we are exceedingly fortunate in having Mr. Jones head of the committee and having the personnel on the committee we have. They are doing far-reaching work for us.

Before taking up the actions on their recommendations, I should like to ask the active members to hold up their hands, so that the action may be official.

(Count made of active members present)

This report is open for discussion and action, and I suggest that we take up the six items one at a time.

MR. JONES: The first item is relative to taking speed. The committee rather felt that in view of the present situation it would

be satisfactory to adopt 24 pictures a second as standard taking speed. The fact remains there are silent pictures, and whether or not it is advisable to supersede that definition or merely to specify the speed for sound pictures is the point on which I should like to have discussion.

DR. MEES: I think it should be made clear that it applies only to 35 mm. film.

MR. R. C. HUBBARD: I don't quite see how we can change our standard completely without mentioning that it has reference to sound film. Certainly, camera men making occasional silent pictures are not turning at the rate of 24 pictures a second.

MR. W. C. COOK: I should like to point out that there is still and likely to continue to be a considerable amount of industrial, educational, and other film taken for silent projection, and I think we should state specifically in the new standard that it is for sound film.

MR. TAYLOR: If that is followed, what is thought about the other?

MR. JONES: The fact that that standard is in a group adopted previous to the beginning of sound technique would indicate that it doesn't refer to sound pictures. It may be desirable in future reprints of our standards to specifically indicate that the 16 pictures per second refers to non-sound film. As a matter of fact, that speed of 16 pictures a second was not very rigidly in practice—it was departed from under certain conditions. In sound film, 24 pictures is rigidly definite and susceptible of standardization.

MR. ROSS: Is it not possible that in the future educational pictures will be accompanied by speech and in which case, they will be recorded at 24 frames a second and that for this reason, eventually all other pictures will come into this class?

MR. CRABTREE: Apparently, in the case of silent films a little speeding up of the action is often necessary, so that taking at 16 and projecting at a higher speed is satisfactory. In the case of the talkies any attempt to hurry along the dialogue is at once perceptible and objectionable.

MR. WALLER: I beg to contradict Mr. Crabtree. I have been in dramatic studios most of my life, and it has been part of my job to watch the camera man. Directors have speeded up the

camera men in order to bring the action back to normal when projected fast, and in the majority of studios the cameras are cranked at 85 to 90 feet per minute, though they thought they were taking at 16 pictures a second.

PRESIDENT PORTER: I should like to point out that according to our rules, any action today is not final; they rest until the fall convention. Are you ready to act on the recommendation of the committee that the taking speed be 24 per second for sound pictures?

(Motion seconded and carried)

MR. JONES: Projection speed to be 24 pictures a second for 35 mm. film.

(Motion seconded and carried)

May I have the first slide again? The third item relates to the position and width of the sound track area on positive film as specified by this dimension drawing (indicating). Before you consider this, I want to point out this thing: The majority of the committee are in favor of adopting this as a temporary expedient, and there are members who object to it. Some do not agree to the adoption of these particular dimensions. In discussing this and voting on it, you should keep this in mind: it is a majority recommendation but not a unanimous one.

MR. R. C. HUBBARD: I think this is too indefinite. I take it that this portion (indicating) should be black, and it doesn't state that. This is the position of the aperture in the projector, which is clearly stated. What is the picture; what is the black portion?

MR. JONES: Item 4 relates specifically to the location and width of the sound track. We are not proposing any standard dimensions for picture area. If I am not correct in that, I should like Dr. MacKenzie to refer to this.

DR. MACKENZIE: Mr. Jones is correct, and the question raised was left open by the sub-committee because certain people feel that the space should be black and others think it is not necessary. In such printers as the Western Electric Company uses one part is light and the other is dark, and it is generally accepted that the sound track itself should be 100 mils wide. For the variable area, as made by the RCA, to accommodate their sound track, it should be a track narrower than 100 mils, bordered by

black on each side. I don't think it is a function of this committee to state whether they should be clear or black.

MR. JONES: We are simply defining dimensions; we are not standardizing whether it should be black or white.

MR. TAYLOR: Mr. Jones has stated that this relates to the sound track, and yet the title relates to the aperture. That was not my principal point. As I recall the wording, it speaks of the emulsion to face and looking at it in a certain way. I have heard a group of men discussing these matters for hours, and I think you can definitely and simply state this so that there will be better understanding if you say the sound track is at the left of the picture. This tells the camera man he will lose from the left and not from the right, which is very important. In special camera work, it tells the man where to put in an aperture, and in designing printers and everything you tie to a particular side of the picture. I think that while this may appear trivial in the use of words, it is very important. Who knows whether you will have emulsion on both sides or a reversal process with the emulsion on the other side. The simple thing is to say that the sound track is on the left side of the picture. The picture is the negative when you look at it, so that you see a picture and not a reversal picture. On the screen you look at the picture and the sound track is on the left side, and the man putting up the screen and everyone else is interested in it, and a great deal of money has been spent on this.

DR. MACKENZIE: I think that is exactly pertinent. I think Mr. Taylor is stating the rules he has to remember. This is for the guidance of the people who are printing it.

MR. TAYLOR: I am not making a recommendation for one man alone. It is for everybody, and I think I have shown you have not defined this fully. When you talk about the emulsion side, suppose some one wants to make 35 mm. negative and develop it to a positive; it isn't a picture, it is a negative.

DR. MEES: Would the committee insert after their statement the words "that is, on the left side of the picture?"

MR. TAYLOR: Is this for the benefit of one particular group or for the whole industry?

MR. JONES: The Chairman has no objection to that phrase, is there any member of the committee present who objects? Apparently, the committee accepts.

DR. MACKENZIE: I am very much in favor of putting in anything which will avoid ambiguity.

MR. EDWARDS: In making provision for a 100 mil track is it necessary that the width between the outer edge and the sprocket hole is only 4 mils? The average theatre finds with that edge of the sound track only 4 mils—our experience shows that the edge of the sprocket hole is fractured and leads into track and the music cuts in on the picture. If there is not some other good reason why can't we have 17 mils clearance on the inside and only 4 on the outside where the source of damage is more prevalent.

DR. MACKENZIE: The 4 mils on the outside was to avoid danger of light striking the sprocket teeth and being reflected and giving a sound of frequency 96 cycles from the perforation. The 17 mils on the other side was what was left over after the present practice of projectors and printers was considered. We know of no reason for recording this 17 as sacred. Considering the practice and the pictures as produced, we thought this the most judicious use of the space if you print on the left side of the 35 mm. film.

MR. EDWARDS: I don't think Dr. MacKenzie quite understood my object. I can't see why instead of having 4 thousandths clearance between the edge and the sprocket hole the track couldn't be moved over, because you have an adjustment for the scanning slit that would permit it.

DR. MACKENZIE: There is an adjustment for the scanning slit located so that it is 54-55 mils from the inside line of the perforations.

MR. EDWARDS: In my Movietone I can move it off the track.

DR. MACKENZIE: Those in the theatres are not that way.

MR. EDWARDS: I can bring my sprocket to make any adjustment on the track; this is standard Movietone apparatus. When the engineers first put it in, they made a mistake and we centered the track and had no further trouble.

DR. MACKENZIE: I should like to see that. Unless I was misinformed, the standard machine is not expected to be so adjusted.

MR. CRABTREE: I see another objection to this small separation between the sound track and the edge of the perforation. During development you can get a flow of developer through the perforations and when developing to low gammas you would be apt

to get a greater degree of development of that part of the sound track, adjacent to the perforations so that gamma would vary across the sound track.

DR. MACKENZIE: That involves an arrangement for widening the whole film, and the committee is not perpared to recommend wider film.

MR. CRABTREE: Under the existing conditions, the flow of developer through the perforations would be worse than the effect of the reaction products of development on the picture.

(An unrecorded remark)

DR. MACKENZIE: What you mean is the guide roller above the sprocket. If the roller is so adjusted that the film comes down vertically, then this diagram applies strictly. If there is a mistake in the adjustment, it will come down askew and adjustment will be closer to the drawing than it was before when the film travelled vertically past the scanning line.

MR. ROSS: If we remember Dr. MacKenzie's paper correctly last fall, he stated that longitudinal lines, white or black, didn't affect the sound record. Why not reduce the width of the sound track, say .010″, making the space between the track and the holes .015″? Would the exposing of one side of the track and the photo-electric cell cause interference with proper reproducing?

DR. MACKENZIE: We thought it would be better located symmetrically. It is not absolutely necessary, but it is desirable to avoid the weave of the film. With a sound track this size there is little clearance on each side. If you had a black edge of the sound track coming to the edge of the scanning line, it would be cutting off the variation.

PRESIDENT PORTER: Are you ready for the question? We are voting on the position of the sound track. Does someone make the motion to accept the recommendation?

(Motion duly seconded and carried)

As I understand it, you skipped the third.

MR. JONES: The scanning line for combined sound and picture shall be 14.5 inches below the picture gate.

PRESIDENT PORTER: Any discussion?

MR. TAYLOR: I think that is another case where you are defining a relative location of the picture and sound on film. The picture exists on film in any position you put it, and I think a better choice of words could be made although I have no objection to 14.5 inches.

MR. JONES: We might consider re-wording that; will you do it?

MR. TAYLOR: I shouldn't attempt to re-phrase it without consideration.

MR. JONES: I will call on the sub-committee then. Have you any suggestion for re-wording this?

DR. MACKENZIE: I haven't studied the objection and couldn't frame an answer.

MR. R. C. HUBBARD: Are you describing relative location of sound and picture on the film, or the location of the scanning frame and picture aperture in the projector?

MR. JONES: We are defining the distance between the point where the sound is being reproduced and where the picture is being reproduced.

PRESIDENT PORTER: The committee recommends that the scanning line be located 14½ inches below the picture gate.

(Motion for adoption made, seconded, and carried)

MR. JONES: The fifth proposition is shown by this slide.

MR. TAYLOR: In spite of the fact that I know some of you are unsympathetic with me, I will run true to form. Mr. Jones explained what I think anybody who has studied this will understand. Since one tooth is in contact, why talk about the number of teeth in contact? My footnote suggestion is that you say "number of teeth in mesh with the film."

MR. CLARK: If you put that on, you have to add one more tooth in the drawing.

MR. TAYLOR: I am willing to have it defined as defined originally.

MR. JONES: The Chairman accepts the word "mesh" in substitution for "contact."

MR. BURNAP: I am not making this as an objection, but the number of teeth in contact is the usual way of speaking. If we say "in mesh" we go off at a tangent and have not defined the thing in question.

MR. TAYLOR: The balance of the definition explains what is meant, and I think in addition to being more accurate it is helpful in that many men don't understand how this works, and if you can bring home to them where the tooth is pulling, it is very helpful.

DR. MEES: Would it be possible to put it in brackets: "number of teeth in mesh (often referred to as 'in contact')." We want to refer to the previous literature to make this clear.

MR. JOHN G. JONES: I think Dr. Mees' suggestion hits the point. Take two gears for example, the number of teeth in mesh are not all in contact.

MR. JONES: Modify the definition then to read as suggested: (Modified definition read)

MR. TAYLOR: Don't you have to go through and say "the greatest number of teeth in contact," because as the sprocket moves it is one tooth more or less?

MR. JONES: I think in reply to that we are trying to clarify the useage of the term which is proper in our literature. The number of teeth in contact is taken as the thing we have defined. If we further complicate it by saying it is the greatest, it is more ambiguous.

MR. TAYLOR: I don't agree.

PRESIDENT PORTER: Are you ready for the question as amended?

MR. CLARK: According to that drawing, if you rotate that two degrees that way, the upper tooth goes out of mesh.

MR. JONES: That is the way they want to define it.

MR. CLARK: How would it be to say "the maxium number of teeth in mesh at any one time?"

MR. FRIEDMAN: If we say at the base of the tooth?

MR. ROSS: I think the title as given is clear because it states that the tooth is in contact, so why assume that the sprocket has moved? The fact is that only one tooth is in contact with the film, the remainder are in mesh.

MR. JONES: The term we are attempting to clarify, because it has been used in the previous literature on standards is the number of teeth in contact with the film. Only one tooth is in contact with the film.

MR. ROSS: Would you please read the revised definition again? (Definition repeated)

It seems to me that the last five words describe the whole thing and make it clear.

PRESIDENT PORTER: I have two suggestions to make here: One is that in view of the fact that only active members are allowed to vote, that the discussion be confined to active members. Also, we are not going to get anywhere by suggesting two or three different definitions, and it is practical to refer this matter back to the committees for further study if the body as a whole is not sat-

isfied with the recommendations. I will ask Mr. Jones to read the proposition again.

(Definition repeated again)

(Adoption moved, seconded, and carried)

Mr. Jones will read the sixth recommendation.

DR. MEES: This particular definition was asked for at the International Congress. Ours will be only one of the different national recommendations, and it is a little unfortunate that it has been necessary to draft it in accordance with the recommendations of the underwriters' Laboratories, because the conditions of test will be different in each country. I shall support it as it is, but I think a new set of recommendations will have to be adopted for the test so that it will be in accord with other people's recommendations. I think for the moment we should adopt this definition.

MR. ROSS: I don't remember that any mention of surrounding temperature was made. Is that important?

MR. JONES: It isn't important; it is very insensitive to temperature.

MR. HUBBARD: There is no mention of the age of the film, which is quite a factor.

MR. JONES: As a matter of fact there are many factors which might be mentioned as having some influence on the burning time. We are trying now to establish some value which will distinguish between a film we wish to call Safety and one non-safety. Of the materials ordinarily referred to as safety film none have a burning time less than 20 seconds, while the nitrate film has a burning time of approximately 4 seconds. There is a very wide gap between the two. The influence of various factors, such as temperature, age, etc. is undoubtedly of a different order than the difference in burning time between the nitrate and the most rapidly burning safety film. It will be remembered that this definition cannot be formulated with the precision of that relating to the international meter. If we should attempt to take into account all possible factors that may influence burning time the definition would become so hedged around with qualifications as to be extremely complicated and difficult of interpretation. We feel that the definition proposed is a reasonable one.

PRESIDENT PORTER: I will ask Mr. Jones to read the recommendation once more.

(Adoption moved, seconded, and passed.)

That concludes the report of the Standards and Nomenclature Committee.

(Applause)

It shows they have been doing a tremendous amount of work.

GLOSSARY OF TECHNICAL TERMS USED IN THE MOTION PICTURE INDUSTRY

ACTINIC—Having the property, possessed especially by the shorter wave lengths of the spectrum, of effecting chemical changes as in photography.

Acoustic Flat—Set Flat treated to secure sound absorption.

Additive process—Color processes in which various hues are obtained by the addition of two or more of the spectral regions comprising white light.

Alternating Current—Current which flows first in one direction and then the reverse, due to the regularly recurring alternation of potential of the generator.

Ampere—The unit of measure of electrical current.

Amplification—The ratio of the voltage or current output to voltage or current input respectively.

Amplification factor—The amplification factor of a three electrode vacuum tube is the ratio of the change in static plate potential to an infinitesimal change in that static grid potential, all other variables remaining constant.

Amplitude—In any vibratory motion, the extent of movement from the mean position to the extreme.

Angle of Incidence—The angle which an incident ray of light forms with the normal to the surface.

Angle of Reflection—The angle which a reflected ray of light forms with the normal to a surface.

Aperture—The opening in the aperture plate at which each individual picture is situated during exposure, printing or projecting respectively.

Aperture Plate—In a motion picture projector, printer, or camera, a plate of metal containing the actual aperture opening.

Arc—A column of very hot light-emitting gas, carrying an electric current sustaining this condition.

Astrogamma—The rate of change of image diameter with log exposure. The slope of the straight line portion of a curve in which diameter is plotted against log 10E.

Attenuation—The inverse of gain measured in the same units as gain.

Back-Focus—The distance from the principal focus of a lens to its nearest face.

Baffle Blanket—Felt Sheets covered on both sides with muslin and distributed about the set to make it acoustically satisfactory for sound recording.

Beat—Interference between two wave trains resulting in alternate reinforcement and destruction of the one by the other.

Bel—Ten Decibels.

Blooping Patch—A triangular black section introduced over a splice on the positive sound track, to prevent the noise which the splice would otherwise cause during reproduction. The patch effects a relatively gradual diminution in the transmitted light, followed by gradual restoration to the original value. The frequency of the diaphragm movement thus caused being below the threshold of audibility, no sound is heard. The patch may be applied by stencilling with black lacquer, or may be a triangle of black paper or film cemented on the track.

Brightness of a Surface—The luminous intensity per unit of projected area.

Bullet-type microphone—A condenser microphone and microphone amplifier mounted in a small case.

Business—Action by the player; e.g., business of shutting door.

Camera Booth—Sound-proof inclosure for cameras employed to prevent camera noises from interfering with recorded sounds.

Camera Marker—The device for marking the picture negative.

Camera Motor—A motor for driving a motion picture camera.

Candle power—The luminous intensity expressed in candles.

Change-Over—In projection, the act of changing from one projector to another preferably without interrupting the continuity of projection.

Cine—A prefix used in description of the motion picture art or apparatus.

Close-up—Scene or action taken with the character close to the camera.

Color Saturation—The ratio of a white light to monochromatic light in a mixture which matches (appears identical with) the color in question.

Color Temperature of a Source—The temperature in degrees abso-

lute (Centigrade degrees +273) at which a true black body will match the color of the source.

Condenser—The lens combination which refracts the diverging rays of the luminant into the projection lens.

Collecting Lens—The lens of the condenser nearest the light source.

Converging Lens—The lens nearest the objective.

Center Lens—The lens of a three lens combination lying between the collecting lens and the converging lens.

Contrast—The ratio of the highest to the lowest value of transmission. The range of tones in a negative or print.

Cooling Plate—A shield or baffle, composed of one or more plates, mounted between the light source and the mechanism, and usually attached to the latter but spaced therefrom, to prevent overheating the mechanism.

Cut-back—Scenes which are returns to previous action.

Cut-in—Anything inserted in a scene which breaks its continuity.

Cutting—Editing a picture by eliminating unsuitable subject matter therefrom.

Decibel—The unit of transmission efficiency which equals ten times the logarithm to the base 10 of the power ratio. Photographic density may be converted into decibels by multiplying by 20.

Density—(Photographic) The logarithm to the base 10 of opacity.

Developing—Chemically treating exposed film to make the latent image visible.

Diffuse density—The value of density in which the total transmitted intensity is measured. (This value of density is applicable to contact printing relations.)

Direct current—An uniform flow of electric current in one direction as from a battery or direct current generator.

Director—The person who superintends the actual production of the motion picture.

Dissolve—The gradual transition of one scene into another.

Distortion (of Sound)—Modification of sound caused by the means employed in its recording and reproduction.

Double Exposure—The exposure of a negative film in a camera twice before development.

Double Printing—The exposure of a sensitive film under two negatives prior to development.

Douser—The fire-proof shutter usually mounted on the lamp house of a motion picture projector or stereopticon by means of which the light may be intercepted before it reaches the film or slide.

Dubbing—The re-recording by electrical means of a sound record or portion thereof. The operation may involve transference from film to wax, wax to wax, or wax to film. Dubbing is resorted to for editorial purposes, for changing volume levels, and for changing the recording medium.

Effective Aperture—The largest diameter of a lens available under the conditions considered.

Electrical filter—A network of electric circuit elements designed to pass or suppress one or more bands of frequencies.

Equivalent Focal Length—The equivalent focal length of a combination of lenses is equal to the focal length of a simple thin lens which will give an image of a distant object of the same size as does the combination lens.

Exciter Lamp—The light source used in reproducing sound from a film.

Exposure—(1) The product of time and the illumination incident upon the photographic material. (2) The placing of any sensitive surface under the action of light.

Exterior—A scene supposed to be taken out of doors.

Fader—A potentiometer connected between the photo-electric cells of two projectors and the vacuum tube amplifiers, employed to change over from one projector to the other at the end of a reel. It is sometimes connected as an inter-stage coupling within the amplifier systems, and in some cases it is also used as a volume control.

Fade-in—The gradual appearance of the picture from darkness to full screen brilliancy.

Fade-out—The gradual but finally complete disappearance of the screen image. (The opposite of fade-in)

Farad—Unit of measure of electrical capacity of a condenser. The usual unit is the microfarad or one millionth of a farad.

Feature—A pictured story—a plurality of reels in length.

Feed Reel—The film reel from which the film is pulled by sprockets or other means before passing thru the sound or picture reproducing or recording mechanism.

Film—The ribbon upon which the series of related picture elements is recorded.

Film-Gate—A movable element which, when in operating position holds the film in register against the aperture plate.

Filter factor—The factorial amount by which exposure must be increased to give the same photographic effect when a filter is used as when it is not used. (*Note.* The quality of the radiation should be the same in both cases.)

Fixing—Making permanent the developed image in a film.

Flash—A short scene, usually not more than three to five feet of film.

Flash-back—A very short cut-back.

Flat—A section of painted canvas, light board, or the like, used in building sets.

Focal length—The distance from the center of a simple thin lens to the image formed by it of a distant object.

Footage—Film length measured in feet.

Foot-Candle—English system unit of illumination. It equals one lumen per square foot—1.0764 milliphot.

Frame—(noun)—A single picture of the series on a motion picture film.

Frame—(verb)—To bring a frame into register with the aperture during the period of rest.

Frame Line—The dividing line between two frames.

Frequency—The number of repetitions per second of a regularly recurring phenomenon such as the alternations of potential in alternating electric Currents or the vibrations which produce light and sound.

Fundamental—The natural frequency of oscillation for an electrical circuit or a material body.

Gain—The ratio of output energy to input energy of an amplification system, usually measured in transmission units or decibels.

Gain control—A device for varying the gain of an electric amplifier. The gain control commonly used in connection with sound reproduction apparatus consists of a pure resistance so designed that the gain can be varied in multiples of one decibel or one transmission unit.

Galvanometer—An instrument for measuring the intensity of an

electric current, for detecting its existence, or for determining its direction. In some sound motion picture systems, the device which converts a variable electric current into an oscillating beam of light.

Gamma—The slope of the straight line portion of the characteristic curve of a light-sensitive emulsion.

Glow lamp—A lamp containing a gas which becomes ionized and glows when the potential between its electrodes reaches a critical value.

Graininess—The effect of inhomogeneity exhibited by silver deposits due to the presence of groups or clumps of silver particles.

Ground noise—Any noise due to foreign matter or imperfections in or on the film arising during manufacture, processing, or handling; does not include amplifier or photoelectric cell noises.

Guide Roller—A roller, one flange of which can move in a direction perpendicular to the direction of film motion and so accommodate variations in width of the film.

Harmonic—A vibration, the frequency of which is equal to the product of the frequency of the fundamental and an integer.

H. & D. Curve—The Hurter and Driffield characteristic curve of an emulsion.

Hue—Refers to the position in the spectrum of the dominant color quality.

Impedance—The property of an electric circuit which tends to oppose the passage of current. Impedance is the resultant of resistance and reactance.

Inertia—The value of exposure at which the straight line of the characteristic curve intersects the Log Exposure axis.

Intermittent Sprocket—The sprocket which engages the film to give it intermittent movement at the picture aperture.

Insert—Any photographic subject, without action, in the film.

Interior—Any scene supposed to be taken inside a building.

Iris—An adjustable lens diaphragm.

Irising—Gradually narrowing the field of vision by a mechanical device on the camera.

Joining—Splicing into a continuous strip (usually 1,000 feet) the separate scenes, titles, etc., of a picture.

Kerr cell—A device consisting of a pair of electrodes in a liquid which in an electrostatic field has the property of rotating the

plane of polarization of a beam of polarized light (used in certain systems of photographic sound recording).

Lambert—A unit of brightness which equals 1/II candle per square centimeter of projected area. The average brightness of a surface emitting or reflecting one lumen per square centimeter.

Lantern Picture—Stereopticon or Lantern picture. A still picture projected on the screen by suitable means.

Lantern Slide—(Stereo Slide)—Stereopticon or Lantern Slide. A single transparent picture designed for projection.

Leader—That piece of blank film attached to the beginning of the picture series.

Lens, Simple—A lens consisting of but a single piece of glass or other transparent medium.

Lens, Compound—The combination of a number of simple lenses.

Light Beam—A bundle of light rays which has a cross section of appreciable size.

Light Ray—A stream of light of inappreciable cross section.

Location—A place other than a studio selected for a motion picture scene.

Loudspeaker—Device into which a varying electrical current is passed after suitable amplification and which transforms this varying current into mechanical vibrations, thereby producing sound waves. Similar to those producing the varying current.

Luminosity curve of a source—A curve showing for each wave length the luminous flux per element of wave length. The product of radiant flux and visibility plotted as a function of wave length.

Luminous Flux—The rate of passage of radiant energy evaluated by reference to the luminous sensation produced—also may be accepted as an entity since velocity may be regarded as constant.

Luminous Intensity—The luminous intensity of a source in any direction is the luminous flux per steradian in that direction.

Magazine Valve—The film opening in the magazine of a motion picture projector.

Marker—A device for marking the negative either photographically or mechanically for locating points of synchronism.

Martens Photometer—The chief example of a photometer in which

polarization is used as a means for varying the brightness of comparison surfaces.

Masks—Opaque plates of various sizes and shapes used in cameras or projectors to limit the effective area of the picture.

Mechanical filter—A mechanical impedance or a combination of mechanical impedances so designed as to pass or suppress mechanical vibrations of certain frequencies.

Micro-Prefix—Meaning the millionth part of, as in micro-farad, micro-ampere, etc.

Microphone—A device for conversion of sound into electrical pulsations.

Microphone Amplifier—The first unit in the amplification chain, usually placed close to the microphone.

Microphone Mixer—An assembly of volume controls used for regulating the relative input signals from several microphones.

Milli—Prefix signifying the thousandth part of, as in millimeter, milli-volt, etc.

Modulation (Electrical)—The variation of amplitude of an alternating current in accordance with the amplitude of a second alternating current or complex wave. As used in sound recording practice the super-position of an alternating current on a direct current.

Monitor—(verb)—To control the volume of sound from a reproducing equipment.

Monitoring Loudspeaker—A loudspeaker located in the recording room and connected with the microphones on the set to permit the recordists to hear the sound being recorded. A similar loudspeaker is placed in the projection room to enable the projectionists to follow the sound reproduction.

Motion Picture—The representation of an object by the rapid presentation to the eye of a series of pictures showing the object at successive intervals of time.

Motion Picture Projector—A device for suitable projecting motion pictures.

Moving period—That portion of the picture cycle during which the film at the aperture is in motion. This period is expressed in degrees of revolution of the fly wheel when 360 degrees are equal to one Cycle.

Multiple Reel Picture—(As applied to 35 m/m film)—A photoplay

of too great footage to be placed on a single thousand foot reel. In practice a term applied to photoplays requiring more than three, one thousand foot reels to hold it; photoplays of two and three reel length being termed "two-reelers" and "three-reelers."

Negative—The developed film, after being exposed in a camera.

Negative stock—Light sensitive film intended for motion picture camera use.

Objective—The simple or compound lens nearest an object which forms an image of it.

Observation Port—An opening in the wall of the projection room through which the projectionist observes the screen.

Ohm—A unit of measure of resistance, reactance and impedance in a conductor to the passage of an electric current.

Optical Axis—The straight line through the centers of the light source, lenses, diaphragm, etc., of an optical system, to which their planes are in general perpendicular.

Optical Scratch—Any particle of dust or mechanical imperfection in the slit will be imaged on the sound track and have much the same effect as a scratch on the sound track parallel to the edges of the film. This is called an optical or shadow scratch.

Optical Wedge—A device which varies progressively in absorption of light from end to end. Sometimes used as a device for varying exposure in sensitometry.

Orthochromatic emulsion—One which is made sensitive to yellow and green as well as blue and violet.

Orthochromatic Photography—Photography in which colored objects are rendered in monotone according to their true visual brightness.

Oscillograph—A device for recording vibrations of high frequency.

Panchromatic—Referring to emulsions which are made sensitive to the entire visible spectrum.

Panoram—To rotate a motion picture camera about an axis perpendicular to the tripod top.

Phase—In uniform circular motion, simple harmonic motion, or in the periodic changes of any magnitude varying according to a simple harmonic law (as sound vibrations, alternating electric currents, etc.) the point or stage in the period to which the rotation, oscillation, or variation has advanced, considered in its relation to a standard position or assumed instant of starting.

Phot—A metric unit of illumination. It equals one lumen per square centimeter.

Photo-electric cell—A cell consisting of a photo-sensitive surface as the negative electrode and a positive electrode between which electrons will flow when the sensitive surface is illuminated.

Photo-electric effect—The emmission of electrons resulting from the action of light.

Photo-electric sensitive surface—A surface which emits electrons under the influence of radiation of certain frequencies. The threshold or minimum value of the frequency necessary to produce photo electrons depends on the composition and the nature of the surface.

Photographic Efficiency of an Illuminant—The ratio of the photographic or actinic flux to the radiant flux.

Photometry—The measurement of light.

Photoplay—A story in motion pictures.

Photo-sensitive surface—Any surface which responds to radiation.

Picture Cycle—The entire series of mechanical operations which takes place between the positioning of one frame of a motion picture film and the positioning of the next frame.

Positive—The developed film, after being printed from a negative.

Pre-release—A picture not yet released for general public showing.

Print—The developed film, after being printed from a negative.

Producer—The maker of motion pictures.

Program—The complete show for a single audience.

Projectionist—A person skilled in the art of projecting motion pictures.

Projection distance—The distance between the projection lens and the surface upon which the image is focused.

Projection lens—The objective which forms upon the screen an image of the lantern slide, film, or other object under examination.

Projection Periods—The total fraction of the picture cycle during which the picture is being projected.

Projection Room—A room or enclosure from which motion pictures are projected.

Props—Contraction of properties. Objects used as accessories in a play.

Q factor—The ratio of specular to diffuse density. Owing to scatter of light by photographic materials, the value of Q is greater than unity.

Reactance—That property of an electric circuit which tends to oppose a varying current without the absorption of energy.

Reciprocity law—Known as the Bunsen-Roscoe reciprocity law which states that the photo-chemical reaction is proportional to the product of intensity and time.

Recorder Marker—The device for marking the sound negative.

Recording Amplifier—A power amplifier used to operate the recording galvanometer.

Recording Drum—The drum over which the film runs as it is exposed in the recorder.

Recordist—Operator of the sound recorder in commercial practice.

Reel—(a)—The flanged spool upon which film is wound.

(b)—An arbitrary unit of linear measure for film—approximately a thousand feet.

Reflecting Power of a surface—The ratio of the reflected intensity to the incident intensity.

Reflector Arc Lamp—In a motion picture projector, an arc light source in combination with a reflector, to project the light beam through the aperture.

Register—To superimpose exactly.

Register—Any indication produced by simulation.

Release—The publication of a moving picture.

Resistance—The property of an electric circuit which tends to absorb energy due to the passage of a current.

Resolving Power of an emulsion—The ability of an emulsion to distinguish detail. Usually expressed as the number of lines and spaces of equal width per millimeter which may be distinguished.

Resonance—Reinforcement of a sound by sympathetic vibration of a material of the same natural period.

Retake—The action of photographing scenes, or the negative resultant therefrom, when the negative or negatives previously obtained are unsatisfactory.

Reverberation—The persistance of sound in an enclosed space. It is measured by the time required for the sound to decrease to one millionth of the initial intensity.

Rewind—The process of reversing the winding of a film, usually so that the end to be first projected shall lie on the outside of the roll.

Rewinder—The mechanism by which rewinding is accomplished.

Safety Film—Film which is less inflammable than the ordinary nitrate film.

Scene—A division of the story showing continuous action in the same locale or set, and usually taken from the same point of view.

Scenario—A general description of the action of a proposed motion picture.

Screen—The surface upon which a picture is optically projected.

Sensitivity—(electric)—The relative efficiency of a device whose response is of a different character from its excitation such as a microphone or photo-electric cell.

Sensitivity—(photo)—The property of photographic emulsion to be rendered developable by the action of light.

Sensitometry (Photographic)—The science of analyzing the response of photographic materials to radiation. The term "sensitometry" as commonly used in the motion picture industry refers to photographic sensitometry. The word itself of course means the measurement of sensitivity and hence may be applied to other things than photographic materials. For instance, visual sensitometry refers to the measurement of the various responses of the eye to radiant energy.

Shadow Scratch—See Optical Scratch.

Sharpness—The rate of change of density with distance from the edge of a photographic image.

Shooting a scene—Photographing the scene.

Shoulder—The over-exposure region of the characteristic curve of a photographic emulsion. In this region a linear relation does not exist between 10g10 Exposure and density. Throughout this region the slope decreases with increasing exposure.

Shutter—A moving element, usually rotating, which intercepts the beam of light in a motion picture camera, projector or printer, one or more times during each cycle.

Single Picture Crank (sometimes referred to as trick spindle)—A crank on a motion picture camera which makes one exposure at each complete revolution.

Slide—(Stereo slide)—See "Lantern Slide."

Slit—The mechanical slit, a part of the optical system, the image of which is focused on the film.

Slit image—The image of the slit produced by the objective lens of the optical system.

Sound Attachment—Any mechanism designed as an attachment to standard projectors to permit reproduction of synchronized sounds and picture.

Sound Gate—A gate similar to that used in picture projectors through which the film is pulled past the reproducing light beam in gate-type machines.

Sound Head—Compartment on the projector which contains sound reproducing systems and mechanism for guiding and driving film.

Sound Negative—Negative on which sound track only is recorded.

Sound-on-disc—A sound motion picture system in which sound is supplied to the picture from a phonography-type record that is run with the picture on suitable turnable apparatus.

Sound-on-film—A sound motion picture system in which sound is synchronously applied to the picture in the form of a sound track photographed alongside the picture frames in definite (or fixed) relation thereto.

Sound Overshooting—As applied to variable area recording, this refers to the condition where the peaks along the sound track extend beyond the limits of the track and are accordingly cut off during reproduction, resulting in deterioration of quality. As applied to variable density recording, it applies to areas of sound track of excessive or incorrect opacity and has a similar result.

Sound Pick-up—Device or system for reproducing sound from film or disc. In sound-on-film, the sound pick-up is an optical-electrical system contained in a compartment on the projector. In sound-on-disc, the pick-up is an electro-magnetic device which transforms the physical variations in the grooves of the disc into electrical variations.

Sound Recorder—An optical-electrical mechanical system for changing electrical impulses, generated by sound striking a microphone, into corresponding light variations that are photographed on the film or into mechanical vibrations which are recorded on a wax disc.

Sound Reproducing—Process of re-creating the recorded sound from film or disc.

Sound Studio—A motion picture studio designed with special wall, floor and ceiling covering to limit reverberations, exclude foreign noises, and give the proper effect to any sounds produced in the studio for recording.

Sound Track—The portion of the film on which the sound is recorded.

Spectrogram—A photographic representation showing the distribution of energy in the spectrum. These are most commonly used to show graphically the spectral distribution of energy and the radiation from a light source, the spectral distribution of energy transmitted by or reflected from selectively absorbing materials, and the spectral distribution of the sensitivity of photographic materials.

Spectrophotometry—The science of measuring the distribution of energy at various wave-lengths.

Specular density—The value of density in which the specular component of transmitted intensity is measured. (This value of density is applicable to projection printing and projection in general.)

Speed—The inverse of inertia multiplied by a constant factor.

Splicing—Joining the ends of film by cementing.

Split Reel—A reel of film of two (or more) parts, the subject of each part unrelated to the subject of the other part.

Spot—The illuminated area on the cooling plate of a motion picture projector.

Sprocket—The toothed cylinder which engages the perforations in the film.

Stationary Period—That portion of the picture cycle during which the film at the aperture is stationary. This period is expressed in degrees of revolution of the fly wheel when 360 degrees are equal to one cycle.

Steradian—The solid angle described by the rotation of a radian about its bisector or an axis.

Stereopticon-Stereopticon or Optical Lantern—An apparatus for optically projecting transparent still pictures.

Still—A picture without movement; e.g., a picture from a single negative.

String galvanometer—A device used in photographic sound recording consisting of a conducting wire or ribbon in a strong magnetic field.

Substandard film—Film whose width is less than the normal 35 m/m.

Subtractive Process—Color processes in which various hues are obtained by the absorption in varying degree of one or more of the spectral regions comprising white light.

Synchronous Disc Attachment—A mechanism designed for attachment to standard projectors to permit running disc records in synchronism with pictures.

Take-up (noun)—The mechanism by means of which a film is wound upon a reel after it has passed through the projector, camera, printer, etc., mechanism.

Take-up (verb)—To wind up the film after it passes the picture aperture in motion picture apparatus.

Take-up Reel—The film reel which takes up the film after it has passed through the sound or picture reproducing or recording mechanism.

Threading-up—The operation of starting the film through the projector, camera, printer, etc.

Throw—See "Projection Distance."

Tilt—To rotate a motion picture camera parallel to the direction of film motion and in a vertical plane through the optical axis.

Time-gamma Curve—A curve in which the value of gamma is plotted against the time of development.

Tinting—Coloring a film by dyeing the gelatine side of it.

Toe—The under exposure region of the characteristic curve. In this region, a linear relation does not exist between log 10 Exposure and density. Throughout this region the slope increases with increasing exposure.

Toning—Coloring a film by chemical action on the silver image.

Transmission Unit—See "Bel."

Trick Crank—See "Single Picture Crank."

Trick Picture—A motion picture intended to give the effect of action other than that which really took place, or to give the impression that the action took place under circumstances other than those which actually prevailed.

Tri-color ratio—The ratio between inertias of an emulsion for violet and blue (wave length—350 to 500 mμ approximately) green and yellow (wave-length 500 to 590 mμ approximately) and red (590 to 700 mu approximately). Acetylene flame screened to daylight quality is usually used as a source.

Trailer—That piece of blank film attached to the end of a picture series.

Unmodulated density—In sound-on-film processes, the density of the developed sound track obtained with the exciting lamp glowing but with its output unmodulated by sound.

Variable Area Sound Track—The type of sound track in which the sound is represented by the irregularity of a boundary line running, in a general way, parallel to the sides of the sound track and dividing it into opaque and transparent areas.

Variable Density Sound Track—The type of sound track in which the sound is represented by parallel lines of varying density of opacity perpendicular to the edge of the sound track and extending across its full width.

Velocity Constant (for development)—The speed with which an emulsion developes

$$\frac{K\text{—}1 \log \frac{Doo}{Doo\text{—}D.}}{t}$$

Vibrator—An oscillograph vibrator used as part of the galvanometer for variable area recording.

Visibility of Radiation of a Particular Wave length—The ratio of the luminous flux at that wave length to the corresponding radiant flux.

Vision—A new subject introduced into the main picture, by the gradual fading-in and fading-out of the new subject, as, for example, the visualization of a thought.

Volt—The unit of measure of electro-motive force, potential, or electrical pressure in a circuit.

Volume control—A variable resistance or other circuit arrangement in the vacuum tube amplifier circuits employed to control the loudness of the reproduced sound coming from the loudspeakers.

Watt—The unit of quantity of electrical power.

Wave length—In any wave motion, the distance between any two

points in the same phase in adjoining waves, e.g., the distance from the crest to crest.

Wax—A soapy-metallic disc, one to two inches thick, on which the first impression of sound in the sound-on-disc process is cut.

Wedge Spectrogram—A spectrogram made by photographing the spectrum through an optical wedge. Used either to indicate graphically the spectral sensitivity of emulsions or the spectral absorption of filters.

Working Distance—The distance between an object and the nearest face of a lens forming an image of the object.

Wow Wows—Change in pitch of the reproduced sound caused by sound film speed fluctuation in either recording or reproducing process. Also known as "flutter."

REPORT OF THE TREASURER

William C. Hubbard, Treasurer

In account with the Society of Motion Picture Engineers

September 20, 1928 to May 1, 1929

DR

To balance on hand, September 20, 1928			$ 7,560.98
Receipts from Dues, Active	$4,122.08		
Associate	1,821.28		
Entrance fees and transfers	5,222.74	11,166.10	
Sales, Transactions	2,190.81		
Reprints	924.13		
Advertising	285.70		
Certificates	8.00	3,408.64	
Balance Lake Pacid Convention fees		164.87	
Interest on bank balances		144.73	14,884.34
			$22,445.32

CR

By Printing and mailing Transactions, reprints, etc.	$ 5,790.91	
Printing and Stationery, supplies, letters, etc.	1,608.28	
General expense, postage, storage, stenographer, insurance, etc.	1,122.29	
Convention expenses, above those items paid from registration fee, at Placid	472.91	
Lapel buttons and certificates	62.64	
Refunds on membership dues (2)	20.00	9,077.03
To balance on hand, May 1, 1929		13,368.29
		$22,445.32

Respectfully submitted,

WILLIAM C. HUBBARD,
Treasurer

REPORT OF THE PROGRESS COMMITTEE—MAY 1929

ONE of the outstanding features of progress during the past six months is the fact that producers and exhibitors have finally realized that the exhibition value of the motion picture is now dependent in no small way on the efforts of the engineer. The industry has gone technical and with the advent of a large number of engineers into the Society from the electrical, radio, and acoustical professions, progress is proceeding at a rapid pace.

The sound motion picture and especially the "talkie" has almost entirely replaced the silent motion picture and there is no reason to believe that the talkie will ever be usurped in favor of the silent picture. The quality of the sound reproduction presented in the average theatre leaves much to be desired, but the improvement in quality effected during the past six months has been remarkable.

Progress in studio technic includes more extensive use of voice doubling, extension of the length of the transmission line between the microphone and the recorder, and the use of more noiseless cameras which do not require the use of a sound proof enclosure. At the present time most of the studios are recording on film and supplying both sound on film and wax records for the theatre. Sound motion pictures are also now available for the amateur in connection with 16 mm. film, the sound reproduction being from wax records.

Producers and exhibitors are now more appreciative of the entertainment value of color in sound motion pictures, especially those of the musical comedy type and several features have appeared with extensive color inserts, one picture of feature length having been produced entirely in color. Most of the color films have been produced by the two-color subtractive method, the dye images being obtained by the imbibition of two dyes into a single gelatin film.

The outstanding advance in color photography was the perfection of the Keller-Dorian process for 16 mm. film which is being marketed under the trade name of "Kodacolor." This process is not yet available for 35 mm. film.

Although a large number of workers are experimenting on the subject of stereoscopy and pseudo stereoscopy, no new stereoscopic processes have been announced during the period covered by this report. Experimenters are also working on wide films so as to produce a much larger and wider screen picture but none have appeared on the market to date.

Research on the subject of television continues but it would appear that until some new fundamental principle is discovered, there is little probability of televized pictures appearing in the theatre in the immediate future.

Respectfully submitted,

J. I. Crabtree, *Chairman*
J. A. Ball
F. A. Benford
L. J. Buttolph
G. L. Chanier
J. W. Coffman
R. E. Farnham
G. E. Mather
R. Rogers

Subject Classification

I. Production

A. Films and Emulsions

1. Nitrate
2. Acetate
3. Panchromatic
4. Duplicating
5. Preservation and Aging
6. Miscellaneous

B. Studio and Location

1. General
2. Lenses and Shutters
3. Cameras and Accessories
4. Light Sources
5. Make-up
6. Exposure and Exposure Meters
7. Trick Work and Special Process Photography
8. Technic of Direction
9. Methods of Recording Sound
10. Actors, Scenarios, Sets, etc.

C. Laboratory Practice

1. Equipment
2. Photographic Chemicals and Solutions

3. Printing Machines and Methods
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I. Production

A. Films and Emulsions

The importance of duplicating valuable negatives, the extensive use of panchromatic film, and the requirements for the photographic recording of sound have resulted in several useful improvements in

emulsion characteristics during the past six months. The properties of panchromatic films of several manufacturers have been discussed.[1, 2, 3] The reports show notable increases in red sensitiveness, thus making the emulsions more useful for sets illuminated with incandescent light. The results on tests on halation, latitude, and other properties of Agfa duplicating film have been published.[4] New negative emulsions especially adapted to the recording of sound have been announced.[5, 6]

A few papers on emulsion technic have appeared. These dealt with principles of continuous drying of emulsion coatings,[7] preparation of highly sensitive negative emulsions,[8] and a résumé of patent specifications.[9]

A review of recent patent literature indicates extensive experimentation on the improvement of cellulose acetate and its derivatives for use as film support.[10] Tests on a new non-inflammable positive film indicate that it lacks the usual brittleness of acetate base.[11] Only a few patents have appeared on improvements in nitrate support.[12] One author describes methods of making cellulose acetonitrate with the object of obtaining the desirable plastic properties of nitrate and the slow burning characteristics of acetate film base.[13]

One additional patent[14] has been accepted to the long group issued during the last few years on methods of improving emulsion sensitiveness by the addition of sulfur compounds during manufacture. Certain protein extracts have also been disclosed as sensitizers for gelatin.[15]

A French patent deals with the application of a plastic heat resisting layer to the emulsion side of photographic films.[16] Several new disclosures have been made concerning treatments of cellulosic film support for the prevention of electro-static charges,[17] and for minimizing halation.[18]

Important suggestions on the standardization of raw film dimensions were submitted by Lummerzheim[19] at the Seventh International Congress of Photography, London, July, 1928. These were related to (1) pitch of perforation and shrinkage, (2) size and shape of perforation, (3) size of film, (4) staggered perforations, and (5) spooling of raw film and core dimensions. Progress has been made on the adoption of standards relating to 16 mm. film and data have been assembled on dimensional standards for film

used in the photographic recording of sound by our Standards and Nomenclature Committee.[20] They have also under consideration the proposals made by the Cinematograph Group at the Seventh International Congress. A few patents have been accepted related to improvements in motion picture film strips for various purposes, such as a means for quick identification,[21] strengthening the perforation area,[22] and attaching paper leaders.[23]

Efforts to modify the usual photographic materials include (1) the use of a translucent paper support,[24] (2) a patent granted on motion picture film having a protected surface and a metallic support,[25] (3) the use of a bichromated instead of a silver image,[26] and (4) the commercial introduction of a diazo compound impregnated viscose film of extreme thinness known as "Ozaphane" film.[27] The last named material contains substances which combine in the presence of ammonia to form a dye but they are decomposed by light. A positive image is therefore obtained directly from a positive.

Funger[28] has published data on edge fog stating Holmolka's explanation of this effect of aging which is said to result from the migration of traces of free soluble bromide from the edges toward the center. A serpentine or wavy leader on motion picture film has been patented which makes contact with the spool flanges at different points as a means of preventing edge fog.[29]

Formulas for hypersensitizing panchromatic materials have been given by Jacobsohn.[30] A new infra-red sensitive film has been announced which is sensitized with "Rubrozyanine."[2]

B. Studio and Location

Uniform diffuse illumination has been suggested for studio lighting whereby the ceiling is a white hemisphere illuminated by spotlights.[31] Descriptions have been published of several German and English studios.[32] The extensive adoption of sound motion picture production programs has resulted in comprehensive changes in studio construction.[33] One producer during the summer of 1928 built an entire new city for making sound pictures exclusively.[34] It comprises 25 buildings covering 40 acres.

Camera Lenses and Shutters. Although many large aperture lenses have been made available commercially, there has been no new fundamental principle of lens design discovered in the last

twenty years.[35] Focal lengths of the taking lens affect the perspective of the projected picture, occasionally introducing serious distortion. The use of large aperture lenses has been reviewed and it is claimed that such lenses are unsuitable for portraiture at distances shorter than about 15 feet.[36] A new f/1.4 objective for cine cameras has been announced which has six elements, two pairs of which are cemented.[37] Several patents[38] on objectives of various types have been taken out related to panoramic work, stereoscopic effects, non-intermittent movements, and alternate use of one of a plurality of lens systems.

The advantages and limitations of various shutter designs have been discussed.[39] Another article dealing with theoretical and practical considerations of the design of claw pull-down movements is of interest.[40] A shutter claiming to reduce flicker and eliminate scattered rays has been patented[41] and has an oscillating beater type of pull-down that makes a friction contact with the film just below the gate.[42] A few additional patents have been issued on various types of pull-down mechanisms.[43]

Cameras and Camera Accessories. Newman[44] has designed a light, automatically driven camera of 200 feet capacity which is claimed to run 160 to 180 feet at one winding of the spring motor. A new camera for both normal and high speed exposures has been developed which carries 25 meters of film, has a 170° shutter, and a hand or spring drive exposing 16 or 50 frames per second.[45] Of historical interest is the description of a camera designed in 1897 to take 100 pictures per second.[46] The film had no perforations and was moved by a rubber friction roller which rotated in one direction and then reversed for a very short time to stop the film. Thun[47] has given a very brief description of his speed camera capable of taking 2,000 pictures per second. Midday sunlight exposures have been obtained at 8-15 feet under water with a De Vry camera enclosed in a metal waterproof box.[48] Two new Debrie cameras have been described recently before the *Society,* one for high speed use and one for professional and news work.[49] To silence the Bell & Howell camera for sound work, fiber gears have been introduced and the film tension set at from 1-1/2 to 2 ounces. A belt tightener was incorporated insuring even take up and bronze substituted for ball bearings.[50]

Sound-proof cabinets for the cameraman are being replaced by sound absorbing coverings over the camera.

A report of the use of the spring drive has been published as applied to several makes of cameras.[51] Four patents have been granted on different types of driving mechanisms.[52] The design of various pressure plates for camera gates have been patented.[53] Rotation of the lens to secure exposure on a wide film in a curved gate has been protected.[54] A professional tripod suitable for supporting the added weight of sound cameras has been made available commercially.[55] Other accessories relate to focusing devices,[56] and modified designs of film magazines.[57]

A black matte varnish for minimizing troubles from reflected light on the interior of lens barrels and camera cases has been described.[58] To facilitate the making of stills during progress of the action, an ordinary camera is attached to a motion picture camera.[59] Reflected images simulating the effect of photographing a subject over an expanse of quiet water are obtained with a cone shaped device which is attached to the front of the camera.[60] A glass plate with a reflecting surface bisects the cone horizontally and the lower half of the cone opening is closed thus causing the upper half of the lens to record the reflected image. Another still camera of especial interest is the stereoscopic camera developed by H. E. Ives.[61] The picture is made from different angles, as the camera is moved along a track in front of a subject. A glass grating with dark lines and clear spaces is placed in front of the sensitive film and a similar grating is placed before the finished picture.

There has been some activity in the use of cameras taking film 70 mm. wide both by Fox and R. C. A. Photophone. The latter in conjunction with G. K. Spoor are stated to be working on a stereoscopic sound film.[62]

A patent has been taken out by the Askania-Werke Akt.-Ges. on a time-lapse camera equipped with special filters.[63]

Studio Light Sources. With the more general adoption of panchromatic negative film stock during the past two years, there has been a gradual increase in the use of incandescent lighting replacing to a certain extent, mercury vapor and arc light units. A studio census taken in February, 1929 showed that a fairly large number of the sixty or more pictures in progress were being photographed with incandescent lamps. On one very large set, over 4,800 lamps

were used, whose wattage totaled nearly four million.[64] Lamps are being used extensively on sets for decorative effects such as signs, tables and wall lights, etc.

Some cameramen have noted less shadow detail with sets illuminated with tungsten lamps only,[65] but further experience is necessary to substantiate these results. An important report has been published of the results of the lighting test experiment conducted by the Academy of Motion Picture Arts and Sciences in conjunction with the American Society of Cinematographers and the Association of Motion Picture Producers.[66] Several interesting general papers on the characteristics of incandescent illumination have been published in our Transactions and in other journals.[67] The 2,000-watt and the 5,000-watt lamps with 18 inch parabolic reflectors are finding extensive use, and a 10 KW. lamp in a 36 inch reflector is being tried out. A new 50 KW. lamp has been described having a chimney-like extension containing radiating disks for heat dissipation.[68] A coarse tungsten powder is being added to the 5 and 10 KW. lamps to reduce the bulb blackening and permit operation of the lamp at a higher efficiency.

Arc lights have been modified extensively during the past two years, especially since the expanded program of sound motion pictures was inaugurated during the spring of 1928. Several types of incandescent "spots," "suns," and "broads" have been described.[69] Some of the spotlights have filter frames operated automatically by electro-magnets. The use of parabolic chromium plated surfaces has increased the light intensity of side arc lamps.[70] Data have been published on the characteristics of flame arcs for studio lighting,[71] as well as a more general paper tabulating the luminous efficiencies of various lighting units.[72]

The neon-arc in combination with the mercury vapor tube appears to offer a light having properties suitable for exposure of panchromatic film.[73] A satisfactory lighting unit is claimed to be obtained by selecting a dye which fluoresces in the red region and coating this on the reflector used with a mercury lamp.[74] Another method of obtaining red radiation is the use of a sodium-potassium alloy which is excited in the same way as a mercury lamp.[75]

Very effective flares[76] for night photography are commercially available which can be ignited by means of dry cells.

Make-up. The art of making-up has undergone extensive

changes with the introduction of panchromatic stock and incandescent lighting equipment. Grease paints must more nearly conform to actual flesh tints.[77] Two valuable articles on this subject by M. Factor and by L. Chaney were published in the Academy Reports No. 1 previously mentioned.[66]

Exposure Meters. In a new model exposure meter of the extinction type,[78] the settings have been chosen to suit normal practice by correlating the principal setting to the exposure time of 1/32 sec. In another optical type meter, the fixed standard of illumination is derived from the impact of radium on a small area of zinc sulfide.[79]

Trick Work and Special Process Photography. In the Fox production "Sunrise," the camera was used to express moods and thoughts, thus avoiding the use of titles wherever possible.[80] A number of patents have been taken out on methods of obtaining trick effects.[81] Effects so protected include among others the use of small size scenery, rotating prismatic lenses, exposure through a blocked-out mask film, pseudo-relief effects, etc. A method of synchronizing several motion picture cameras with one sound-recording device has been patented.[82] A novel method of composite photography which was described recently before the Society permits double exposure (without phantom effects) into miniature action or into distant location shots.[83]

Many unusual effects obtained in motion pictures are introduced during printing, and special optical printers have been designed.[84] In one process backgrounds are inserted with the use of a traveling matte.[85] An automatic focussing device adaptable to either horizontally or vertically mounted title or cartoon cameras has been described by Norling.[86] Distortion effects not present in the negative may be introduced according to one patent, by the use of a prism having an aspherical lenticular face.[87] A few patents dealing with methods of making composite pictures have been issued.[88] Of interest to workers doing special process photography where slight variations in shrinkage of films result in serious distortion of images, is a new graduated gauge which gives a direct reading of the pitch of any film by simply laying the film on the gauge.[89]

In sound recording work voice doubling has been accomplished, particularly in the case of songs and instruments where the rhythm

makes it possible. Information[90] has been published on revocalized films wherein a method is described of redistributing sounds on a phonograph record to bring them into synchronism with the picture, or objectionable sections may be eliminated. Bristol has also dealt extensively with a method of re-synchronization of sound.[91]

Direction Technic. Very little information of a reliable nature has been published on the technic of directing pictures. Two papers published by leading directors in Hollywood, therefore, are especially valuable, since they recount difficulties and problems encountered under the stress of actual production.[92] A valuable analysis of the director's problems with relation to sound technic has been made by Wm. de Mille.[93]

Sound Recording. The making of sound pictures has revolutionized the motion picture industry during the last year. Nearly all the large producers have committed themselves, in part, to a production program and one has announced exclusive production of sound pictures. Four types of sound pictures have been classified by Millikan:[94] (1) musically scored pictures; (2) pictures with songs; (3) news reels; (4) dialogue pictures.

Besides the studios erected by one producer for sound picture production, mentioned previously,[34] J. A. Ball has reported in a letter to the Chairman of the Committee the installation of 33 recording channels by two companies both for sound on film and wax disc methods. Portable units for recording are being delivered and one picture "In Old Arizona" was taken with portable equipment entirely in open, desert country. Another picture was made in the South Seas with very light portable apparatus; the amplifier unit weighed only 22 pounds and was operated with dry cells, the entire aparatus being transported by canoes.

A historical review of the development of sound pictures has been published.[95] An analysis of E. A. Lauste's early patent specification, granted in 1906, indicates that this inventor had grasped many of the essentials of photographic sound recording as used at the present time.[96] The variable area sound recording system used by the General Electric Company has been described by Marvin.[97] Wente[98] has reviewed the principles of sound recording and Steinberg[99] has discussed the qualities of speech and music.

Besides the use of a glow lamp, variable density records are also produced with a constant light source in conjunction with a slit,

the width of which is varied according to electrical modulations created by the sound waves to be recorded. Sound recording with a slit of this type known as a light valve has been described by MacKenzie.[100] A description of another type of light valve called the "Kerr Cell" has also been given.[101] Hardy [102] has dealt with the optics of sound recording systems. Wax recording methods have been described by Frederick.[103] The intricate equipment necessary to insure synchronization of sound and picture during recording has been described by Stoller.[104] Koller[105] has written on the use of the photo-electric cell and Kellogg[106] on the vacuum tube.

Descriptions of sound recording processes in use abroad include variable density record types, one the invention of A. J. Roberts[107] and another known as the Küchenmeister system.[108] Others are the Gaumont-Peterson-Poulson process[109] whereby the sound and picture are recorded separately, and a somewhat similar system called the "Meisterton" process.[110] In this latter process the recording is done with a Reisz microphone on a separate negative in a sound camera which is synchronized with the picture camera. The amplified microphone current is recorded with a constant width slit and Rühmer's singing arc lamp which operates on a constant direct current and is activated by having the amplified microphone current impressed on the constant supply. The sound record is of the varying density type.

Tri-Ergon[111] Sound Films also yield a variable density record obtained with a "glow-lamp," but a film of 42 mm. width is used.

Causes of ground noises, extraneous sounds recorded by the film, have been analyzed by Sandvik[112] who showed that the processing conditions, even though very carefully controlled, introduce considerable ground noise. A giant amplifier installed on an airplane made clearly audible to persons on the ground the voice of a man speaking in ordinary tones when the plane was at an elevation of two thousand feet.[113] An amplifying system installed in the Central Casting Bureau at Hollywood, California, in conjunction with the telephone switchboard makes possible the segregation of any voice for testing purposes for sound pictures.[114]

In Hollywood, according to J. A. Ball's report, there has also been a considerable extension of the length of the transmission line between the point of recording and the point of pick-up. Pick-up has frequently been extended to the back lot of the studio and

instances have been mentioned of it having been done over telephone lines for considerable distances but the degree of success is not known.

Instead of using a separate film for the reproduction of the sound, or a very narrow track on which the smallest defect is of considerable importance, Establissements L. Gaumont are reported to be working on a method for reproducing the sound image on a thin film coated with bichromated gelatin.[115] After treatment the gelatin relief is dyed with esculine and cemented with gelatin on the back face of the scene film. The base of the latter is thinner than the usual stock and the pictures are made up exclusively of dyes transparent to the ultra violet, which is absorbed by the esculine. The stimulation of the photo electric cell by the ultra violet is not interfered with by the scene image, and the cinematographic projection is not impeded by the esculine which is transparent to visible radiations.

The desirable properties of glass windows for sound proof booths have been discussed.[116] An opaque film with the picture record on one side and the sound record on the opposite side has been described; both images are projected by reflection.[117]

Certain difficulties encountered in acoustic measurements of the performance of loud speakers have been described.[118] Because of the nature of these difficulties it has not yet been possible to specify a complete and simple set of measurements or conditions which will completely express the performance of a loud speaker. Data have been given showing the performance of two representative types of loud speakers both when measured in outdoor space free from reflections and when measured under varying conditions in a specially treated acoustic laboratory. The differences serve to emphasize the importance of certain precautions in the making of indoor acoustic measurements.

A radical experiment in sound picture production is contemplated in New York. It consists in remaking a picture in French immediately after the English version has been completed. French actors from the French theatre will be used. Similar plans are under way for actors of other nationalities to make foreign distribution of American sound pictures possible.[119]

Numerous patents have been issued dealing with a great many phases of sound recording processes.[120]

A detailed historical review of sound-on-disc and sound-on-film patents has been published which is of considerable interest in connection with the present extensive application of sound motion pictures.[121]

Actors, Scenarios, Sets. Although over 11,000 persons are registered at the Central Casting Bureau, Hollywood, only about 900 are employed daily.[122] Producers draw on this bureau for extra actors. The technical equipment and processes involved in making a picture from the scenario writer's view are clearly set forth by Carey Wilson.[123] Nauman[124] has demonstrated the value of reflecting power measurements for standardizing materials used in set construction. Pentagonal towers mounted on wheels permit rapid change of sets as five different scenes may be arranged.[125] A simple apparatus for generating ammonium chloride gas fog effects has been described by Seeber.[126] Crystallized hypo or sodium thiosulfate has found a use as artificial ice for motion picture sets.[127] It produces a dry, glossy surface, melting at 118°F. and scores under the pressure of a skate very much like ice.

C. Laboratory Practice

Equipment. Continuous negative developing machines have been installed by several laboratories. A typical machine has been described by Hunter.[128] A compact, horizontal tray type of developing machine has been designed by Jamieson.[129] A tube machine made in two sizes is being manufactured in Germany.[130] Small, portable outfits for developing short lengths of standard film are available commercially,[131] one of a reel and tank design, and another a spiral developing frame.

Motion picture films taken at the Republican Convention at Kansas City were developed in an airplane during a flight to New York City.[132]

A number of patents have been granted dealing principally with improvements in the design of continuous machines and with portable developing equipment.[133]

A description of the various types of voltage regulators for laboratory and studio service has been prepared by Byles.[134] A photometer for the precise measurement of low intensity, darkroom illumination has been devised by Jones and Lowry.[135]

Photographic Chemicals and Solutions. New information on

photographic solutions is rather meager. Reports of tests on the Kodak borax fine grain developer have been generally favorable. Namias[136] also suggests a formula devised by O. Mente. Another formula has been published anonymously.[137] Glycin is suggested as a good developer for tests on color sensitivity of panchromatic emulsions.[138] Dundon and Crabtree[139] have dealt extensively with the fogging properties of developers showing that desensitizers give complete protection against aerial developer fog. Results of an investigation by Luther[140] support the theory that the specific action of soluble bromides is opposed to the reduction potential of a developer. According to Rzymkowski,[141] the protective action of sulfite in a developer (hydroquinone) is the result of the formation of an addition compound with the reducing agent molecule which compound is oxidized in preference to the developing agent.

Printing. Specifications for a standard notch for a printer light change were recommended at the Seventh International Congress, London, July, 1928.[142] A printer using a continuously moving film without optical compensation has been described, two designs being suggested applicable as well to projectors.[143] In one model the film moves tangentially near the edge of a disc so that the exposures are made through helical slots in the disc which expose the film from one side to the other as it advances. In a second arrangement the film moves radially across the surface of a disc which has radial slots of length equal to the height of a frame and which move across the film every time the film advances one frame. Both methods produce consecutive single pictures in the shape of a parallelogram. Emmermann[144] has published a general paper on the usefulness of the optical printer. An article has appeared giving calculations of the friction and strain imposed on film at various speeds at the aperture of motion picture machines.[145] Several patents deal with improvements in printer design.[146]

Quantitative data have been worked out by Tuttle[147] relative to the printing intensity of several lamps and methods of varying the intensity of such lamps have been considered.

Valuable notes on making duplicate negatives have been published by Ives and Huse with reference to the use of duplicating film.[148] The use of color wedges for varying the contrast in the printing of duplicate negatives has been protected by Capstaff.[149]

The importance of strict supervision of the processing of sound films has been stressed by Coffman[150] who gives also valuable data on the design of developing machines and the composition of developing solutions.

The printing of sound motion picture films has resulted in many modifications in printer design, a number of which have been patented.[151]

Stereoscopically related pictures may be printed according to a patent specification describing a special printer for the purpose.[152]

Tinting and Toning. A single solution dye toning formula has been suggested by Crabtree and Ives containing, besides the dye, acetone, ferricyanide and acetic acid.[153]

Editing and Splicing. Two devices for editing film have been described, each of which projects an image on a viewing window.[154] In one of them a still picture is projected without the use of an intermittent or a shutter, a rotating spiral mirror and a series of plane mirrors being used. A few patents related to splicing and editing apparatus have been granted.[155]

Title Making. A method of introducing backgrounds in titles has been described which consists in photographing a projected motion picture and subsequently printing in the title matter either by double exposure or double printing.[156]

Cleaning, Reclaiming, Rewinding, and Storage. A multiple synchronous rewind has been devised permitting the simultaneous rewinding of three picture films and their corresponding sound film.[157] Only three patents were thought to be of interest in connection with methods of cleaning and reclaiming film.[158] A container for storing film has been patented, the novelty of its design being a trapped recess in the walls connecting with the outer air.[159]

II. Distribution

To facilitate distribution, a producer makes two negatives of each picture; from one, 200 prints are made for American circulation; from the other which is shipped to England, about 140 prints are made for European use.[160] Forty-four Film Boards of Trade have been established by the Motion Picture Producers and Distributors of America to aid in film distribution.[161] Over seven hundred institutions receive the benefit of showings of free film.

III. Exhibition

A. General Projection Equipment

Projectors and Projection. Each year, manufacturers of projection equipment have been endeavoring to make their apparatus more silent when running. With the advent of sound pictures, this feature becomes increasingly important and one firm recently demonstrated a machine especially designed for sound film projection.[162] Two other new projectors have been made available for which certain advantages are claimed.[163] A projection device, called the "Triptique" permits simultaneous projection of three pictures to give either a panoramic view or three separate inter-connected pictures.[164] A very rigid supporting stand for projectors has been designed which has six adjustable leveling points.[165] An exhaustive comparison made between arc lamps with glass condenser systems and mirror arcs has been published and the results favor the arc lamp as being the most efficient illuminating unit.[166] Calculations based on the best available arcs and optical systems show that 8,000 lumens is the maximum attainable light flux for screen illumination, only half of which is practically available.[167]

A number of patents [168] have been granted covering various improvements in projector design, among others claw pulldown movements, arc illumination, mechanism for reversing film, modified maltese cross design, etc.

Faulty projection conditions in theatres have been denounced by a meeting of the Technicians' Branch of the Academy of Motion Picture Arts and Sciences, although opinions were expressed that the indifference of some producers toward the theatre was partly to blame. The strict supervision necessary for sound pictures will alleviate the situation.[169] Imperfect drying of the film and excessive heat on the film as it passes through the projector gate causes film buckling and it is suggested that the shutter should be placed between the light source and the gate in order to reduce the temperature.[170] An analysis has been made by Naumann of temporary in- and out-of-focus effects during projection.[171] A projector equipped with a variable gate capable of handling different sized films has been patented, for example large films with two sets of marginal perforations or narrower films centrally perforated.[172]

Fire Protection. A patent has been granted for a device which directs a blast of moist, oil-free, cool air on the gate of a motion picture projector.[173] The characteristics of heat absorbing glasses have been described.[174] A description has been published of the projection rooms in the Paramount Theatre, New York City, with especial reference to the precautions for fire prevention.[175] A survey of the causes of projection room fires in a large city during one year provides valuable information for the projectionist.[176] A fire extinguisher has been so mounted on a projector that it puts the fire out almost instantly and cuts off the electric current to the projector.[177] Another automatic apparatus closes the light circuit and stops the projector whenever the path of the film becomes slightly changed.[178] Valuable hints on installation of projection room equipment have been given which if adopted are claimed to permit a 50 per cent reduction in insurance costs.[179] Data have been published showing the time required to quench burning celluloid with water.[180] A few patents have been issued pertaining to the design of projection apparatus to minimize fire hazards.[181]

Effect Projection and Stage Illumination. Effect projectors enable very beautiful scenic designs to be created for stage presentation. A simple apparatus for the embellishment of titles has been described.[182] A twin lamphouse universal effect projector makes possible more complex and unusual design effects.[183] Projection on very large gauze drops has been used effectively at the Eastman Theatre for prologue acts as well as the occasional use of very large screens filling the entire proscenium arch.[184] The importance of complete co-ordination of light and music is stressed by Powell, who describes installations for creating certain color effects.[185] Three articles have appeared giving descriptions of a number of new devices for stage lighting.[186] Landau suggests the introduction of "color music" by choosing twelve colors corresponding to twelve tones in an octave.[187] Kann has patented the lateral projection of images for decorative purposes in theatres.[188]

Projector Lenses and Shutters. Hauser and Mohr[189] have reviewed the optical paths and objective requirements in motion picture projectors. A general survey of modern lens design with special emphasis on projection lenses has been published by Lee.[190] Several new types of projection lenses have been described.[191]

A silvered plate of optically clear quartz on which a network

of fine lines have been cut through the silver is suggested as a suitable test object for testing projection lenses.[192]

A cylindrical shutter rotating on a horizontal axis and positioned between the film and light source is claimed to reduce the heat at the gate aperture at least 6.5 per cent.[193] Several patents claiming certain novel improvements in shutter design have been granted.[194]

B. Special Projection Equipment

Sound Film Projection. Approximately 2,500 sound projection installations had been made up to April 15, 1929, one firm reporting nearly 1,700 separate installations.[195] The introduction of sound pictures has greatly changed the character of the motion picture theatre. All the technic of the motion picture has now become available to be added to the machinery of the drama.

Encouragement to the small exhibitor is offered by one firm which has announced sound devices selling between $3,500 and $6,000.[196] Several types of electric turn-table reproducers have been made available, some of which are equipped with means for synchronizing the pictures and the sound.[197] A description has been published of a portable sound device for reproducing various sounds, such as airplane motors, machine gun fire, etc.[198]

A new design speaker working on an organ pipe principle has been described which is so designed as to be a decorative feature of the theatre.[199] Minton and Maloff [200] have dealt with recent developments in the design of dynamic loud speakers. A description of the equipment used for sound reproduction by Western Electric and details for its installation have been published by Scriven and Santee.[201] Difficulties encountered in measuring the acoustic properties of loud speakers have been discussed by Bostwick,[202] and by Engl.[203]

An indicator has been designed for sound picture projection which shows the number of feet per minute and the minutes consumed per thousand feet of film.[204]

New types of exponential horns have a conversion efficiency from electrical to sound energy varying from 10 per cent to 50 per cent in the frequency range of 60 to 7,500 cycles.[205] A description has been given of a compact power amplifier designed to provide field current to a dynamic loud speaker.[206]

A number of articles have appeared dealing with the technic of projection of sound pictures, both with the "record-on-film" and disc types.[207]

A note published in July, 1928, mentioned that sound films in color would be available in the near future.[208] A color sequence with sound was included in the picture "Broadway Melody" released in the spring of 1929. The sound was reproduced from a disc record.

There have been quite a number of patents issued pertaining to various phases of sound film projection.[209]

Projection of Stereoscopic Pictures. Lane[210] has described a novel projector for stereo, color and standard films, a demonstration of which was given at the last meeting of the *Society*. Only four patents have been noted dealing with the projection of pictures yielding relief effects; none of the patents represents essentially new principles.[211]

Non-Intermittent Projection. The number of patents and articles on continuous projectors appearing in the last few months indicates a renewed interest in this method of projection. Leventhal[212] has published two papers, one of a general character considering the advantages of continuous projection and another describing in detail a new optical compensator. Another optical projector has been designed on a more elaborate scale by A. J. Holman.[213] Mirrors have been eliminated in this projector, the bending of the light rays being accomplished entirely by refraction. Two other non-intermittent projectors have been announced although the descriptions given of them are rather meager.[214] Improvements in the design of the Mechau projector were described in a recent article.[215] Longer projection life for films is claimed by the manufacturers of this apparatus. A comparatively large number of patents have been granted relating to the design of continuous projectors.[216]

Portable Projectors. A combination projector and screen enclosed in an upright cabinet is finding commercial use for advertising purposes; 16 mm. film in 1,000 foot reels is used.[217] Another 16 mm. projector has been equipped with a carrying case fitted with a small translucent screen for use of the traveling salesman.[218] A portable projector weighing 25 pounds and using 35 mm. film has been announced.[219] Patent protection has been obtained by several inventors of portable projection equipment.[220]

C. Miscellaneous

Screens. A new screen has been announced for which better acoustic properties and projection qualities are claimed.[221] A rear projection screen is available commercially which is made by coating a cloth with a liquid of known surface tension and applying a filler which refracts and disperses the light from the projector.[222] Several patents[223] have been taken out for various types of projection screens, including, among others, a screen coated contiguously with calcium tungstate, a method of application of transparent red, yellow and blue dyes or pigments to yield a neutral tint, screens composed of several layers of white net, the use of perforated oilcloth, etc.

Theatre Construction. The stage has contributed much to theatre design as certain factors are essential for adequate presentation of motion picture plays.[224] This is even more true with the acceptance of sound pictures, for the acoustics of the auditorium are now equally as important as the decorative motif. A unique departure from the customary design of motion picture theatres is the new Film Arts Guild playhouse in New York.[225] It has screens along the sides and ceiling with a white screen at the front, thus permitting the projection on the walls and ceiling of pictures in harmony with the action of the feature. A little theatre movement for the showing of artistic and unusual pictures is beginning in America, having been initiated according to Tazelaar[226] at the Vieux Colombier, Paris, in 1924.

Mobile color designs are possible now in a Brooklyn theatre since the installation of a Clavilux color organ.[227]

Schutz has presented suggestions on building a motion picture auditorium.[228] The value of placing reproducing horns in various parts of the theatre as well as behind the screen is stressed by Rigaumont.[229] Accounts of the factors which determine the acoustic properties of rooms have been published by Parsons[230] and by Heyl.[231]

Plans of a proposed double theatre, each half seating 5,000 persons, have been reproduced.[232] Rear projection on large screens would be possible from a central projection room located between the two auditoriums. Six projectors arranged in two tiers of three each would project segments of the picture on the large screen. Three patents related to projection location and design in theatres have been granted.[233]

IV. Applications of Motion Pictures

A. Education

A new course in *Photoplay Appreciation* was inaugurated in February, 1928, at the University of Southern California as a joint project with the Academy of Motion Picture Arts and Sciences.[234] A sound motion picture dealing with aspects of the movies and ideals of the industry was shown before the Chicago convention of the National Association of Teachers of Speech as a forerunner to similar pictures for University circulation.[235]

Although meeting with some opposition in a few countries, educational films are finding valuable adaptation in Japan, Hungary, and the United States according to several reports.[236] An important experiment in classroom films of two years' duration was culminated successfully during the summer of 1928. Over 10,000 pupils participated, half of which were taught with the aid of films specially prepared. A 33 per cent gain in geography and a 15 per cent gain in science resulted in classes using films.[237]

A general outline has been published of the details necessary for making a technical film.[238] An informative article by Warstat[239] has appeared giving suggestions to the amateur ciné workers for making carefully planned pictures in several fields such as botany, zoology, physiology, hygiene, etc.

A sound motion picture has been prepared at the U. S. Army Infantry School at Fort Benning, Ga.[240]

A school of visual education has been initiated where films and an amateur standard projector are sent to the student instead of the usual textbooks and folders.[241]

A summary of progress in the educational field has been prepared by Rowland Rogers and is published as an appendix to this report.

B. Medical Films, Radiography, and Photomicrography

The motion picture provides a valuable means for studying nervous disorders according to Lewis[242] who also gives a brief review of the work of Jelliffe, a neuropsychiatric specialist. Two papers describing arrangements for making surgical motion pictures have appeared, one by Degner[243] and another by Tuttle and Morrison.[244] X-ray pictures of human organs have been made using a reducing camera and motion picture film.[245] The visible rays on

a luminous screen are photographed directly. By means of the "osciographoscope," slight changes of heart pulsations may be photographed by a motion picture camera, and the heart sound recorded on a phonograph record.[246] The device combines the x-ray, the stethoscope, and the motion picture camera.

Two arrangements for adapting a small motion picture camera for the photomicrography of biological specimens have been described by Schenunzky.[247] A view finder and a camera mounting have also been made available for adapting any camera for motion photomicrography work.[248] Tuttle and Trivelli[249] have made motion photomicrographs of the progress of development of the individual silver bromide grains in a photographic image.

C. Telephotography and Television

The problems of transmission of ordinary photographs are so closely related to television that mention of progress in telephotography is felt to be justified in this report. Photographic sound records of three spoken words were transmitted by telephone across the continent to New York where the records were reassembled and incorporated in a sound film showing at one of the theatres.[250]

It is now possible to transmit a picture five by eight inches in 48 seconds or a message at the rate of 630 words per minute according to Zworykin.[251] In the transmitting device, a very efficient optical system supplies to the photo-electric cell enough light reflected from the picture so that only three stages of resistance coupled amplification are necessary between the cell and modulator.

A detailed description has been published of the Fultograph system whereby the negative to be transmitted is printed on a zinc or copper cylinder coated with a resist of sensitized fish glue.[252] A stylus passing over the surface transmits an electric current which is recorded at the receiving end on electrically sensitive paper.

A brief account has been published of the transmission of a simple play by the Alexanderson system of television.[253] Regular schedules of radio movies have been established by the Jenkins Laboratories, Washington, D. C., for the transmission of silhouette images which later will be replaced by half-tone or shaded motion pictures.[254] A demonstration of radio motion picture transmission was given on August 8, 1928, in the Westinghouse Laboratory, signals being transmitted about four miles.[255] Broadcasting of ordin-

ary motion pictures was successfully accomplished by station WCFL, Chicago, a 48 hole scanning disc revolving at 900 revolutions per minute being used.[256]

Direct scanning of subjects by a moving beam of light is claimed to permit the use of a very intense transient illumination and more than one large aperture photo-electric cell to collect the reflected light.[257]

A new type of scanning device for television transmission and reception has been announced.[258] The device is based on the use of a circular disc which is so mounted that it can be rotated simultaneously both about its center and about one of its diameters. The disc is mounted in a forked support in which it can be rotated at a high speed, and then the base of the fork is mounted in bearings so that the fork and disc as a whole can be rotated at some other speed. On the periphery of the disc, photo-electric cells are mounted, depending on whether the device is to be used for transmission or reception. An odd number of these tubes is used, five being suitable, the tubes being spaced at equal intervals. It is claimed for this system that any degree of definition of the received image may be attained with ease. It is also stated that an image as large as that of a moving picture can be reproduced with the same degree of clearness.

A description of a process of television in natural colors has been published.[259] Three exploring spirals, each covered by a daylight filter are arranged consecutively around one scanning disc. The filters transmit green, red, and blue light respectively, the subject being scanned first by a red spot of light, then by a blue spot and last by a green spot. The receiving station has a similar disc in synchronism with the transmitter and includes a neon tube (red) and two separate glow discharge lamps made from a combination of helium and mercury vapor (blue-green).

Several patents have been issued mainly in Great Britain on television apparatus.[260]

D. General Recording

The "cavitation" or movement of bubbles along the surface of propellor or turbine blades has been photographed by reflected light from the bubbles.[261] A unique 15 horse power motor (8 cm. by 28 cm.) was developed for driving the camera. Fleming[262] has de-

scribed an apparatus for photographing sound studies of buildings. General instructions have been prepared on the use of the motion picture camera for recording data from various measuring instruments.[263] Hausler[264] has published comprehensive papers on the use of cinematography for making rapid general geographical surveys.

The recording of stress patterns in glass and celluloid by polarized light has been accomplished with motion pictures.[265] Russell[266] has made a beautiful time-lapse study of the rotation of the planet, Jupiter.

Motion pictures at one second intervals showed that the rate of fall of a dummy thrown from an airplane remained at 120 miles per hour throughout the entire fall.[267] A camera using 16 mm. film has been devised for photographing the checks handled each day by a bank.[268]

V. Color Cinematography

There have been no outstanding advances recorded in the field of professional color motion pictures. Lehmann and Kofes[269] in a long general article have reviewed the possibilities of two-color additive and subtractive methods and have concluded that a two-color subtractive process is in general the more satisfactory. The method of manufacture of Lignose color screen film has been described by Emmermann.[270] Patents related to three-color cinematography[271] are in general concerned with methods of making multi-color screens, successive exposure through primary filters, and exposing through prisms to produce three images on the area normally occupied by one picture.

A short description has been published of the working principles of the Kellar-Dorian process which uses film on the support side of which horizontal cylindrical lenses of 1/60 mm. diameter are embossed.[272] Exposure is made through a three-color diaphragm, the film being threaded in the camera with the emulsion side away from the lens. Patent protection has been granted for a number of improvements in processes using embossed films.[273]

Bourquin[274] has given description of the Wolff-Heide two-color additive process. Pictures are taken with an ordinary motion picture camera at 28 frames per second, using film which has alternate frames sensitive to red and blue, respectively. Alternate frames of the print are dyed and the film projected at 24 frames per second.

A few patents of interest pertaining to two-color additive methods have been issued.[275]

The changing patterns produced by a suitable grouping of colored elements moving slowly past the end of the kaleidoscopic prism have been reproduced by Jones and Tuttle, [276] using a two-color subtractive process. The use of such color film for embellishment of theatre programs is suggested.

Mudrovic[277] has conducted an investigation on sensitizers and dyes suitable for use in the bleach-out process whereby film is coated with a mixture of three primary color dyes which bleach out in proportion to the amount and color of the exposing light.

A chemical process called Pathéchrome has been announced to replace the old stencil process of Pathécolor.[278]

Subtractive color processes for which patents have been issued recently are related to imbibition printing, apparatus for exact registering of two films, production of double-width, double coated film for recording two pairs of images in four colors, etc.[279]

VI. Amateur Cinematography

A. General

Cameras. A new spring driven camera taking 12 meter lengths of 16 mm. film has been described by Neumann.[280] Darkroom loading is required as both the drive and take-up reels are incorporated in a single metal magazine. Another new camera has been made to take 50 foot lengths of film but a new film having a thin base is also being supplied in 100 foot lengths.[281] A spring driven 16 mm. camera which is equipped for normal, slow motion, and trick exposures has been announced. It is equipped with an f/2.6 lens adjustable for all distances to one foot.[282]

Two spring driven cameras taking 9½ mm. films were made available recently; one has a vertical oscillatory shutter for making the exposure,[283] and the other carries 8 meters of film which can be exposed at one winding if desired.[284]

Projectors. A silent running 16 mm. projector has been marketed which is fitted with a barrel-type shutter and claws having a double eccentric action.[282] Three other amateur projectors for 16 mm. film have been made available; one model is hand-cranked.[285]

Accessories. New accessories for the cine amateur include a lens turret accomodating three lenses,[286] a combination bridge table

and movie screen,[287] electrically equipped console cabinets for storing camera, projector, film, splicer, etc.,[288] an audible footage meter,[289] and various types of incandescent and arc lights.[290]

Sound movies in the home may now be realized since the introduction of a phonograph turn table operated from an extension shaft to the projector to maintain synchronism.[291] A magnetic pick-up transfers the sound record to the audio amplifying system of an ordinary radio receiver.

Scenarios, Amateur Movie Clubs. About 80 amateur photoplays were completed by approximately twenty-five amateur clubs during the year 1928.[292]

Film Processing. Solutions for developing amateur films by the reversal method have been recommended by Henri-Robert.[293] Two patents are of interest relating to equipment for continuous processing of amateur films. A controlled exposure[294] is given the film after the first development by passing the film over a light responsive element such as a thermopile which is excited according to the density of the film. The other patent describes a complete processing machine.[295]

B. Color Processes

An additive process of three-color cinematography for the amateur using 16 mm. film was announced in August 1928.[296] A three-color filter is used on both the standard camera and projector and a series of tiny cylindrical lenses are embossed vertically on the film support. The film is threaded in the camera with the emulsion side away from the lens so that the light passes through the embossed lenses before it reaches the emulsion. Each minute lens element images the three-color filter diaphragm and thus exposes one, two, or three lines on the film according as the subject reflects one, two, or all three primary colors. On projection, the lens elements and the filters serve to recombine the colors of the original subject. The film is developed by a reversal process.

In another new amateur color process, alternate color records are exposed on a film moving 26-28 frames per second, through a rotating sector wheel, each filter of which is made up of seven sectors of different colors.[297] A reduction in color fringing and improved color rendering is claimed.

VII. Miscellaneous Uses, Statistics, New Books

A valuable use for the cine camera has been found in the portrait studio, contact transparencies being printed from single negatives on 35 mm. film.[298] These transparencies are then enlarged to the required size for printing. A novel enlarger and printer apparatus have been devised.

During the year from July 1, 1929 to June 30, 1930 a limit of 210 feature films can be imported into Germany; no restrictions have been made on news reels and short comedies.[299] It is estimated that over 163 million dollars will be invested in theatre building during 1929.[300] A questionaire returned by 20,000 patrons of a New York movie theatre revealed that over half the patrons came on their friends' recommendation.[301]

More than 325,000 persons in the United States depend on the motion picture industry for their livelihood.[302] An arbitration system established within the industry handled over 15,000 dispute cases during 1927.

A glossary of terms used in studios in connection with the making of motion pictures has been assembled.[303]

New books appearing during the last year and a half are listed below:

1. Die Kinematographische Projektion, by H. Joachim. W. Knapp, Halle, 1928.
2. Der Trickfilm Vol. 2, by G. Seeber. Licht Bild Bühne, Berlin, 1927.
3. Motion Picture Photography, by C. L. Gregory. 2nd Edition, Falk Publishing Company, New York, 1927.
4. Der Tönende Film, by Jo Engl. F. Vieweg & Sohn, Braunschweig. 1927.
5. Der Sprechende Film, by F. Von Mihaly. M. Krayn, Berlin, 1928.
6. Talking Movies, by J. R. Cameron. Cameron Publishing Co., Manhattan Beach, New York, 1928.
7. Motion Pictures with Sound, by J. R. Cameron. Cameron Publishing Company, Manhattan Beach, N. Y., 1929.
8. Amateur Movie Craft, by J. R. Cameron. Cameron Publishing Co., Manhattan Beach, N. Y., 1928.
9. Amateur Movie Making, by H. C. McKay. Falk Publishing Co., New York, 1928.
10. Motion Picture Theatre Management, by H. B. Franklin. Doran, N. Y., 1927.
11. Color Photography, by O. Wheeler. I. Pitman & Sons, Ltd., London, 1928.
12. Practical Color Photography, by E. J. Wall. 2nd Edition, Amer. Phot. Publishing Co., Boston, 1928.

APPENDIX

Progress in the Educational Field During the Past Year

Rowland Rogers

I. Introduction

To secure a comprehensive view of recent progress in the use of pictures in the educational field, some background is essential. There are about 25,000,000 children of school age in the United States. Twenty million or about 80% attend school for an average of about 140 days each year for about 7 years. About 90% of our American children leave school at the end of the seventh grade. We are a nation of seventh graders.

Some Problems. In light of these facts what are a few of the problems?

1. Students lack of ability to comprehend the instruction given.
   Slowness or inability of students to grasp the teacher's meaning.
2. Teacher's lack of ability.
   Inability of teachers to get over their meaning and make their subject interesting.
3. Lack of teachers.
   Inadequately trained teacher personnel.
4. An over-crowded curriculum.
   A curriculum which is crowded with too many subjects, resulting in lack of time for teacher and pupil to cover the subject adequately.
5. Over-crowded classes.
   Too many students in a class.

II. The Value of Visual Instruction

1. Student's lack of ability to grasp. The subject is "over their heads." Frequently students lack a background of knowledge. Say the subject of study is in economic geography, and for example nut margarine: Here information about cocoanuts is needed. The child may know little about the tropics. The picture may show a cocoanut tree growing in the tropics; a man native climbing the tree, the cocoanuts being gathered; shipped in rafts, opened, and

the copra packed and shipped to the United States. The picture is vivid and interesting. While showing cocoanuts, the student learns something about the tropics, its vegetation, its people, their appearance, habits, customs, method of dress. Visual instruction may supply their background knowledge, and so bring the subject within the scope of the child's experience.

The student may lack interest. The subject may lack reality and clearness. Pictures frequently bring such a graphic, compelling human portrayal of the subject that student interest is aroused and maintained.

2. Teacher's lack of ability. The teacher may be well informed, but lacking in the human touch, the knack of "getting over." Lighted pictures are an effective tool in the teacher's kit, which lend color and vividness to the program, and help her to get her instruction across.

3. Lack of teacher's training. Over 100,000 teachers in the United States have only an elementary school education. These are not adequately trained for their jobs. While no teaching device however good, can make good this loss, yet the poorly prepared teacher is able by the use of visual devices, to give her pupils a minimum standard of instruction. The greater her ability, the richer becomes her program of instruction when she uses visual aids.

4. The over crowded curriculum. Recall that the average number of years a child in the United States goes to school is 7, and the average number of school days each year is about 140; that the High School student is in school only 4% of his time. Then compare the ever increasing list of subjects being taught in elementary and high schools. With this background, the need for the wider use of effective time- and labor-saving devices with which to reach the objectives of education, is immediately apparent. Visual aids are effective tools to help an over crowded curriculum. In the use of visual aids, there is an actual saving of time needed to impart a given amount of knowledge.

5. Over crowded classes. Many students may see large, lighted pictures, either stills or movies, at one time, without loss of interest or discipline. The use of pictures is adapted to specialized instruction and the use of the platoon system. Thus they help solve the problems of large classes.

III. The Results of Visual Instruction

A marked growth has resulted during 1928 in the field of visual instruction. The most significant fact is the scientific proof of the value of visual instruction. Eastman Teaching Films conducted an experiment on about 10,000 children in a dozen different cities. About 5,000 were taught in the regular way. About 5,000 more had the advantage of visual aids. The gain from the use of visual aids ranged from 15% to 33%.

The other gains were:

1. These films arouse and maintain greater interest.
2. They increase the quantity and improve the quality of reading, project work, classroom discussion and writing.
3. They help pupils to correlate materials more thoroughly.
4. They increase the richness, accuracy and meaningfulness of experience.
5. They facilitate the teacher's work of organizing lesson materials, and add to the pleasure and interest of teaching.

The second important fact is the increase in the number and suitability of motion pictures prepared for instruction.

Eastman announces films on Geography, such as fisheries, dairying, wheat, cotton, coal, etc.; in General Science, on atmospheric pressure, purifying water, limestone and marble, etc.; also films on chemistry, biology, manual training and civics.

Pathé offers among others, films on courses in Geography, Music Study, Nature Study, Aviation and Physical Education.

DeVry offers eight complete courses including Health and Hygiene, Electricity, Vocational Guidance and Citizenship.

The above lists indicate the variety of subject matter. A number of other producers are making and distributing educational films, etc. Harvard University has announced the formation of the Harvard Foundations for the production of instruction films. A start has been made at headquarters in Cambridge, Mass.

Both Eastman and Bell & Howell have announced new models of projectors directly adapted to school use.

Conclusion. 1928 showed marked progress in the educational field. It is fair to state that educational films have secured a firm hold in the educational field.

References

1. C. Emmermann and K. Brandt, Filmtechnik *4* (May 26, 1928) pp. 205-8.

2. C. Emmermann and K. Brandt, Filmtechnik *4* (Oct. 27, 1928) pp. 423-5; also K. Jacobsohn, Phot. Ind. *26* (Apr. 4, 1928) pp. 374-5.

3. C. Emmermann and K. Brandt, Filmtechnik *4* (Oct. 13, 1928) pp. 405-7.

4. C. Emmermann and K. Brandt, Filmtechnik *4* (May 12, 1928) pp. 183-6.

5. Amer. Cinemat. *10* (Apr. 1928) p. 28.

6. Exhib.-Herald World *95* (Mar. 2, 1929) Adv. Back Cover.

7. G. Kail, Phot. Ind. *26* (Sept. 26, 1928) pp. 981-3.

8. K. Kieser, Z. angew. chem. *41* (Dec. 8, 1928) pp. 1292-5.

9. P. Knoche, Phot. Ind. *26* (Sept. 26, Oct. 3, 24, 31, 1928) pp. 987-90, 1012-4, 1092-3, 1116-18.

10. U. S. Pats. 1,687,060; 1,683,347; 1,683,831; 1,690,620; 1,690,621; 1,690,632; Brit. Pats. 287,635; 288,782; 289,523; 289,853; 289,973; 290,571; 291,001; 291,360; 291,386; 292,398; 293,629; 293,316; 293,724; 294,008; 294,251; 294,415; 294,572; 295,797; 297,676; 298,819; 299,326; 299,512; 300,140; 300,824; 300,942; 301,036.

11. L. Eveleigh, Bioscope Supp. 77 (Oct. 31, 1928) p. III.

12. Br. Pats. 289,387; 300,551; 300,552.

13. Krüger, Phot. Ind. *26* (July 4, 1928) pp. 690-2.

14. Ger. Pat. 458,286.

15. U. S. Pats. 1,667,589; Brit. Pats. 271,039; 272,867; Ger. Pat. 448,775.

16. Fr. Pat. 637,675.

17. Fr. Pats. 635,152; 635,281; 635,828; also U. S. Pats. 1,680,635; 1,683,315; 1,687,041; 1,687,042.

18. Brit. Pats. 292,990; 294,104.

19. H. Lummerzheim, Sci. et Ind. Phot. *8A* (July 1, 1928) pp. 74-7.

20. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 899; also Brit. J. Phot. *75* (July 20, 1928) pp. 436-7.

21. Brit. Pat. 300,991.

22. U. S. Pat. 1,683,830.

23. U. S. Pats. 1,687,044; 1,687,048; 1,687,066; 1,687,100.

24. Amat. Movie J. *1* (May 1928) p. 8; also O. Treickel, Phot. Ind. *26* (Aug. 22, Oct. 3, 1928) pp. 855-6; 1009-11.

25. Ger. Pat. 457,458.

26. J. W. Coffman, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 379-81.

27. Kinemat. Weekly *137* (July 19, 1928) p. 29; also Filmtechnik *4* (March 31, 1928) pp. 118-9.

28. A. Funger, Phot. Ind. *25* (Nov. 23, 1927) pp. 1203-4.

29. U. S. Pat. 1,690,739.

30. K. Jacobsohn, Das. Atelier *35* (Oct. 1928) pp. 110-12.

31. C. Emmermann, Photo. Chronik *35* (July 31, 1928) pp. 301-3.

32. M. Colin, Revue Cinemat. franc *10* (Sept. 22, 1928) pp. 121-4; L. Eveleigh, Amer. Cinemat. *9* (Oct. 1928) p. 9; Film Spiegel *9* (July 1928) pp. 5-7.

33. J. B. Engl, Trans. Soc. M. P. Eng. *12* No. 33 (1928) p. 103; Frank Woods, ibid *12* No. 35 (1928) p. 625; P. E. Sabine, ibid. *12* No. 35 (1928) p. 809; F. S. Crowhurst, ibid. *12* No. 35 (1928) p. 828; J. G. Motley, Bell Lab. Record *6* (June 1928) p. 322.

34. Mot. Pict. News *38* (Oct. 6, 1928) p. 1093.

35. W. B. Rayton, Trans. Soc. M. P. Eng.*12* No. 34 (1928) pp. 335-44.

36. H. Boehm, Amer. Ann. Phot. *42* (1928) pp. 15-22.

37. W. Merte, Kinotechnik *10* (Sept. 5, 1928) pp. 452-3.

38. U. S. Pat. 1,680,498; Brit. Pats. 289,998; 290,563; U. S. Pat. 1,672,222.

39. G. T. Miller, Bioscope Supp. *77* (Oct. 17, 1928) pp. V-VII.

40. A. S. Newman, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 410-18.

41. U. S. Pat. 1,697,429.

42. Ger. Pat. 463,260.

43. U. S. Pats. 1,673,120; 1,680,295; Fr. Pats. 634,637; 638,569; 638,893; Ger. Pat. 461,776.

44. A. S. Newman, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 397-402; also Kinemat. Weekly *139* (Sept. 20, 1928) p. 74.

45. Filmtechnik *4* (Oct. 27, 1928) pp. 434-4.

46. A. Lassally, Kinotechnik *9* (Nov. 20, 1927) pp. 588-95.

47. R. Thun, Phot. Korr. *63* (Dec. 1, 1927) pp. 374-7.

48. F. D. Crosby, Trans. Soc. M. P. Eng. *12 No.* 36 (1928) p. 1083.

49. Trans. Soc. M. P. Eng. *12 No.* 36 (1928) pp. 1168 and 1169.

50. Amer. Cinemat. *9* (Mar. 1929) p. 13.

51. G. Seeber, Filmtechnik *4* (Oct. 27, 1928) pp. 420-2.

52. U. S. Pats. 1,674,522; 1,691,419; Brit. Pat. 289,093; Ger. Pat. 463,689.

53. Fr. Pats. 636,624; 637,950; Brit. Pat. 290,315.

54. U. S. Pat. 1,693,722.

55. J. L. Spence, Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1159; also M. P. News *38* (Oct. 6, 1928) p. 1069.

56. E. M. Mueller, Amer. Phot. *22* (Oct. 1928) pp. 569-70; also Ger. Pat. 457,847; U. S. Pat. 1,686,204.

57. U. S. Pats. 1,685,802; 1,686, 204.

58. G. Labussière, Rev. franc. phot. *9* (Dec. 1, 1928) p. 351.

59. M. Duverger, Rev. franc. phot. *9* (Dec. 1, 1928) pp. 351-2.

60. Sci. Amer. *140* (April 1929) p. 376.

61. Film Daily *46* (Nov. 1, 1928) p. 1; also J. Opt. Soc. Amer. and J. Sci. Inst. *17* (Dec. 1928) p. 435.

62. Film Daily *47* (Feb. 24, 1929) p. 1.

63. Ger. Pat. 457,425.

64. R. E. Farnham, Amer. Cinemat. *10* (April 1929) p. 31.

65. Bull. Acad. M. P. Arts and Sci. No. 13 (Aug. 1928) p. 4.

66. Acad. Reports No. 1. "Incandescent Illumination." Acad. M. P. Arts and Sci., Hollywood, Calif., 1928.

67. F. Benford, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 484-501; R. E. Farnham, ibid. *12* No. 34 (1928) pp. 464-83; P. Mole, ibid. *12* No. 34 (1928) pp. 521-36; L. Bloch, Phot. Korr. *64* (July 1, 1928) pp. 219-23; C. Emmermann, Filmtechnik *4* (May 12, 1928) pp. 180-3; K. Jacobsohn and F. Thiele, Filmtechnik *4* (May 26, 1928) pp. 203-5.

68. Mot. Pict. Projectionist *1* (Sept. 1928) p. 5.

69. Ex. Herald and Mov. Pict. World *93* (Dec. 22, 1928) p. 34; also A. J. McGregor, M. P. Projectionist *1* (July 1928) p. 18; Trans. Soc. M. P. Eng. *12* No. 36 (1928) pp. 1190-92.

70. Amer. Cinemat. *9* (Nov. 1928) p. 18.

71. D. B. Joy and A. C. Downes, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 502-20.

72. L. A. Jones and M. E. Russell, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 427-52.

73. F. Benford and L. J. Buttolph, Trans. Soc. M. P. Eng. *12* No. 36 (1928) pp. 1010-21; also Kinotechnik *10* (May 20, 1928) p. 276.

74. L. Eveleigh, Bioscope Supp. *76* (July 25, 1928) pp. VII-IX.

75. Filmtechnik *3* (Aug. 20, 1927) p. 322.

76. Amer. Cinemat. *9* (Oct. 1928) p. 15; also Trans. Soc. M. P. Eng. *12* No. 36 (1928) pp. 1195-97.

77. K. A. Barleben, Jr., Amer. Phot. *22* (Aug. 1928) p. 452.

78. Brit. J. Phot. *75* (Aug. 17, 1928) p. 502.

79. C. H. Clarke, Phot. J. *68* (Aug. 1928) p. 366.

80. K. Struss, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 317-9.

81. U. S. Pats. 1,669,936; 1,690,039; 1,696,431; Re. 17,125 of 1,576,854; Brit. Pats. 289,507; 296,391; 296,686; Ger. Pat. 459,039; Fr. Pat. 636,802.

82. Ger. Pat. 460,669.

83. C. D. Dunning, Trans. Soc. M. P. Eng. *12* No. 36 (1928) pp. 975-79.

84. C. L. Gregory, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 419-26.

85. F. Williams, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 537-40.

86. Trans. Soc. M. P. Eng. 12 No. 36 (1928) p. 1088.

87. U. S. Pat. 1,669,027.

88. U. S. Pats. 1,669,407; 1,680,534; 1,686,987.

89. Sci. et Ind. Phot. *8* (Dec. 1, 1928) p. 199, Lummerzheim, Kinotechnik *10* (July 5, 1928) pp. 352-55.

90. E. Hopkins, Trans. Soc. M. P. Eng. *12* No. 35 (1928) pp. 845-52.

91. W. H. Bristol, Trans. Soc. M. P. Eng. *12* No. 35 (1928) pp. 778-89.

92. C. B. De Mille, Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 295-309; I. Willat, ibid. *12* No. 34 (1928) pp. 285-94.

93. Wm. de Mille, Amer. Cinemat. *9* (March 1929) p. 17.

94. Rochester Times-Union, Dec. 5, 1928, p. 8.

95. O. Messter, Kinotechnik *10* (Oct. 5, 1928) pp. 499-506.

96. L. Eveleigh, Bioscope Supp. *77* (Oct. 24, 1928) pp. IX-X.

97. Amer. Cinemat. *9* (Oct. 1928) pp. 18-20.
98. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 657.
99. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 633.
100. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 730.
101. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 748.
102. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 760.
103. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 709.
104. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 696.
105. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 921.
106. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 948.
107. Kinemat. Weekly *142* (Dec. 6, 1928) p. 71.
168. U. S. Pats. 1,668,589; 1,669,427; 1,672,845; 1,674,629; 1,677,237;
109. A. P. Richard, Cinemat. franc. *10* (Oct. 27, 1928) p. 45.
110. E. W. Nack, Kinotechnik *10* (Sept. 20, 1928) p. 475.
111. Licht Bild Bühne *21* (June 30, 1928) p. 17.
112. Trans. Soc. M. P. Eng. *12* No. 35 (1928) pp. 790-98.
113. Mot. Pict. Projectionist *1* (Sept. 1928) p. 25.
114. Mot. Pict. News *38* (Oct. 6, 1928) p. 1406-E.
115. Sci. et Ind. Phot. *8A* (Nov. 1928) p. 123; also Brit. Pat. 297,733.
116. W. B. Rayton, Amer. Cinemat. *9* (Jan. 1929) p. 8.
117. Amer. Cinemat. *9* (Feb. 1929) p. 11.
118. L. G. Bostwick, Bell System Tech. J. *8* (Jan. 1929) p. 135.
119. Rochester Times-Union, April 15, 1929.
120. Fr. Pat. 638,280; U. S. Pats. 1,679,708; 1,680,653; 1,693,071; Brit. Pats. 287,086; 288,225; 289,446; 290,171; 290,564; 290,962; 291,105; 293,381; 295,034; 295,379; 295,603; 297,407; 298,079; 298,158; 300,235; 300,913; 301,082; Ger. Pats. 455,045; 458,177; 459,573.
121. Film Daily *47* (Feb. 24, 1929) p. 6, et seq.
122. Mot. Picture *4* No. 6 (1928) p. 2; also F. W. Beetson, Trans. Soc. M. P. Eng. *12* No. 33 (1928) p. 81.
123. Trans. Soc. M. P. Eng. *12* No. 33 (1928) p. 58.
124. Trans. Soc. M. P. Eng. *12* No. 34 (1928) p. 310.
125. Kinemat. Weekly *134* (Apr. 19, 1928) p. 55.
126. Filmtechnik *4* (Nov. 14, 1928) p. 262.
127. Sci. Amer. (Apr. 1929) p. 377.
128. Trans. Soc. M. P. Eng. *12* No. 33 (1928) p. 195.
129. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1093.
130. Kinotechnik *10* (Oct. 5, 1928) p. 515.
131. Camera Craft *35* (July 1928) p. 336; Phot. Ind. *26* (July 4, 1928) p. 694.
132. Kinemat. Weekly *137* (July 19, 1928) p. 59.
133. U. S. Pats. 1,674,185; 1,686,907; Ger. Pats. 457,459; 465,318; Fr. Pats. 633,835; 634,221; 634,949; Brit. Pats. 289,833; 299,793; 300,496.
134. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 980.
135. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1054.
136. Il. prog. fot. *35* (1928) pp. 253-6.
137. Photo-Revue *39* (Dec. 15, 1927) p. 187.

138. A. P. Richard, Cinemat. franc. *10* (Sept. 22, 1928) pp. 127-8.
139. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1096.
140. Phot. Ind. *26* (June 13, 1928) p. 626.
141. Photo. Ind. *26* (June 13, 1928) p. 627.
142. K. Geyer, Licht Bild Bühne *21* (1928) p. 18.
143. M. Adam, Kinotechnik *10* (Sept. 20, 1928) pp. 480-2.
144. Filmtechnik *4* (Sept. 29, 1928) pp. 390-1.
145. R. Thun, Kinotechnik *10* (June 20, 1928) pp. 324-8.
146. U. S. Pats. 1,676,600; 1,692,347; Brit. Pats. 288,970; 289,526; 290,721; 297,130; Fr. Pat. 636,620; Ger. Pat. 462,636.
147. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1040.
148. Trans. Soc. M. P. Eng. *12* No. 34 (1928) pp. 382-9.
149. U. S. Pat. 1,690,617.
150. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 799.
151. U. S. Pats. 1,668,856; 1,695,415; Brit. Pats. 289,419; 290,668; 292,063; 296,816; 300,996.
152. Brit. Pat. 300,143.
153. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 967.
154. Phot. Ind. *26* (Feb. 29, 1928) p. 236; also P. Hatschek, Filmtechnik *4* (May 12, 1928) pp. 187-9.
155. U. S. Pats. 1,670,447; 1,672,214; 1,672,542; 1,685,904; 1,695,857; Brit. Pats. 288,123; 300,274; Ger. Pat. 460,622.
156. S. Riker, Filmo Topics *4* (Nov. 1928) p. 7.
157. Amer. Cinemat. *10* (Feb. 1929) p. 7.
158. U. S. Pats. 1,676,299 and 1,692,358; Ger. Pat. 458,215.
159. Ger. Pat. 461,016.
160. Amat. Phot. (London) *66* (Oct. 31, 1928) p. 398.
161. Mot. Pict. *4* No. 7 (1928) p. 4.
162. Film Daily *46* (Nov. 22, 1928) p. 1.
168. U. S. Pats. 1,668,589; 1,669,427; 1,672,845; 1,674,629; 1,677,237; 59; ibid. *29* Sect. 2 (July 7, 1928) p. 39.
164. R. H. Cricks, Kine. Weekly *137* (July 19, 1928) p. 77.
165. Ex. Herald and Mov. Pict. World *91* Sect. 1 (Apr. 28, 1928) p. 26.
166. R. Dahlgreen, Kinotechnik *10* (Aug. 20, 1928) pp. 427-31.
167. H. Naumann, Filmtechnik *4* (Oct. 27, 1928) p. 425.
168. U. S. Pats. 1,668,589; 1,669,427; 1,672,845; 1,674,629; 1,677,237; 1,691,475; 1,692,092; Brit. Pats. 290,164; 290,248; 292,604; 294,543; 295,733; 296,414; Fr. Pats. 633,944; 634,102; 638,461; Ger. Pats. 427,791; 455,165; 459,284; 460,192; 460,668; 462,566.
169. Bull. Acad. M. P. Arts and Sci. No. 13 (Aug. 1928) p. 3.
170. Mot. Pict. News *38* (Dec. 15, 1928) p. 1830.
171. Kinotechnik *10* (Feb. 20, 1928) pp. 93-5.
172. Brit. Pat. 287,341.
173. Brit. Pat. 280,161.
174. H. P. Gage, Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1063.
175. H. Rubin, Amer. Projectionist *6* (Feb. 1928) p. 6.

176. Amer. Projectionist *6* (Aug. 1928) p. 16.

177. Exhib. Herald and Mov. Pict. World *93* Sect. 2 (Oct. 27, 1928) p. 101.

178. R. Dahlgreen, Kinotechnik *10* (Nov. 20, 1928) p. 576.

179. E. A. Rovelstad, Exhib. Herald and Mov. Pict. World *92* Sect. 2 (Sept. 1, 1928) p. 55.

180. A. Helle-Staux, Kunststoffe *18* (May 1928) p. 114.

181. U. S. Pat. 1,682,627; Brit. Pats. 297,452; 299,760; 300,449; Fr. Pats. 637,330; 637,903; Ger. Pats. 441,081; 460,299.

182. C. L. Greene, Amer. Projectionist *6* (Aug. 1928) p. 7.

183. J. H. Kurlander, Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 998.

184. L. M. Townsend and W. W. Hennessy, Trans. Soc. M. P. Eng. *12* No. 34 (1928) p. 345.

185. Mot. Pict. News *37* (June 2, 1928) p. 1861.

186. Kinemat. Weekly *134* (Apr. 26, 1928) pp. 37 and 69; ibid. *141* (Nov. 22, 1928) p. 72.

187. Cinemat. franc. *10* (July 28, 1928) p. 25.

188. Fr. Pat. 635,115.

189. Filmtechnik *4* (Jan. 21, 1928) p. 23-6.

190. Amer. Cinemat. *9* (Nov. 1928) p. 7.

191. Mot. Pict. Projectionist *2* (Oct. 1928) p. 29; Phot. Korr. *64* (May 1, 1928) p. 155; Rev. franc. phot. *9* (Dec. 1, 1928) p. 352.

192. Mot. Pict. Projectionist *1* (Mar. 1928) p. 18.

193. Exhib. Herald and Mov. Pict. World *93* Sect. 2 (Oct. 27, 1928) pp. 121-2.

194. Brit. Pats. 291,946; 293,397; 293,882; 299,403.

195. Exhib. Herald-World *95* (April 27, 1929) p. 39.

196. Mot. Pict. News *38* (Dec. 1, 1928) p. 1639.

197. Mot. Pict. News *38* (July 7, 1928) p. 41; ibid. *38* (Nov. 17, 1928) p. 1520; ibid. *38* (Aug. 11, 1928) p. 460-B; Kine. Weekly *136* (June 28, 1928) p. 75; ibid. *137* (July 5, 1928) p. 62; ibid. *138* (Aug. 23, 1928) p. 46; ibid *141* (Nov. 1, 1928) p. 71; Exhib. Herald and Mov. Pict. World *92* Sect. 2 (Sept. 29, 1928) pp. 17 and 38.

198. Mot. Pict. News *38* (Dec. 8, 1928) p. 1755.

199. Mot. Pict. Projectionist *2* (Oct. 1928) p. 25.

200. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 836.

201. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 666.

202. Bell System Tech. J. *8* (Jan. 1929) p. 135.

203. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 853.

204. Exhib. Herald and Mov. Pict. World *93* Sect. 2 (Oct. 27, 1928) p. 76.

205. J. G. Uzmann, Mot. Pict. Projectionist *2* (Oct. 1928) p. 7.

206. Mot. Pict. News. *38* (Dec. 1. 1928) p. 1657.

207. Mot. Pict. News *39* (Jan. 12, 1929), p. 102; Trans. Soc. M. P. Eng. *12* No. 35 (1928) pp. 867 and 872; Exhib. Herald and Mov. Pict. World *92* Sect. 2 (July 7, 1928) pp. 19-22; ibid. *93* Sect. 2. (Oct. 27, 1928) p. 19; Bio-

scope Supp. *76* (Sept. 26, 1928) pp. X-XII; Mot. Pict. Projectionist *1* (Mar. 1928) p. 7; ibid. *1* (Apr. 1928) p. 33; *1* (June 1928) p. 9; *1* (July 1928) p. 27.

208. Mot. Pict. News *38* (July 7, 1928) p. 31.

209. U. S. Pats. 1,673,217; 1,674,946; 1,675,122; 1,678,568; 1,695,414; Brit. Pats. 289,447; 289,448; 292,462; 292,610; 293,380; 294,558; 295,378; 299,894; Fr. Pat. 635,538; Ger. Pat. 455,084.

210. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1034.

211. Brit. Pat. 297,941; Fr. Pats. 635,835; 636,175; Ger. Pat. 463,813.

212. Trans. Soc. M. P. Eng. *12* No. 34 (1928) p. 406; ibid. *12* No. 36 (1928) p. 1068.

213. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1184.

214. Mot. Pict. News *38* (Aug. 4, 1928) p. 369; also Kinotechnik *10* (Feb. 20, 1928) p. 109.

215. Trans. Soc. M. P. Eng. 12 No. 36 (1928) p. 1193.

216. U. S. Pats. 1,673,250; 1,673,251; 1,673,252; 1,685,646; 1,687,193; 1,688,607; 1,689,266; 1,690,770; Brit. Pats. 287,274; 290,372; 292,113; 293,630; 296,669; Fr. Pats. 634,197; 635,841; 636,312; 636,495; 637,220; Ger. Pats. 462,884; 464,509; 465,066.

217. Kinemat. Weekly *140* (Oct. 4, 1928) p. 77.

218. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1175.

219. New Phot. *11* (July 7, 1928) p. 349.

220. U. S. Pats. 1,667,724; 1,684,968; 1,689,802; Fr. Pat. 638,055; Ger. Pat. 458,142.

221. Exhib. Herald-World *93* (Dec. 1, 1928) p. 29.

222. Kinemat. Weekly *134* (Apr. 26, 1928) p. 65.

223. U. S. Pats. 1,672,656; 1,676,553; 1,686,880; Brit. Pats. 294,850; 295,400; 295,581; Fr. Pat. 637,641; Ger. Pat. 455,288.

224. A. O. Gibbons, Kine. Weekly *141* (Nov. 1, 1928) pp. 35-7.

225. Exhib. Herald and Mov. Pict. World *93* Sect. 2 (Dec. 22, 1928) p. 11; ibid. *94* Sect. 2 (Mar 16, 1929) p. 15.

226. Movie Makers *3* (July (1928) p. 441.

227. Mot. Pict. News *38* (Dec. 1, 1928) p. 1668.

228. Exhib. Herald and Mov. Pict. World *93* Sect. 2 (Dec. 22, 1928) p. 9.

229. Mot. Pict. News *38* (Aug. 4, 1928) p. 366.

230. Exhib. Herald and Mov. Pict. World *92* Sect. 2 (July 7, 1928) p. 9.

231. Trans. Soc. M. P. Eng. *12* No. 35 (1928) p. 823.

232. Kinemat. Weekly *141* (Nov. 1, 1928) p. 9.

233. U. S. Pat. 1,681,723; Fr. Pat. 637,145; Ger. Pat. 459,285.

234. Bull. No. 18, Acad. M. P. Arts and Sci., Jan. 1929.

235. Bull. No. 17, Acad. M. P. Arts and Sci., Dec. 1928.

236. Ed. Screen *7* (Nov. 1928) pp. 229 and 236; ibid. (Dec. 1928) p. 268.

237. Amer. Cinemat. *9* (Nov. 1928) p. 16.

238. Kinotechnik *10* (Feb. 5, 1928) p. 75.

239. Kinotechnik *9* (May 30, 1927) p. 277.

240. Mot. Pict. Projectionist *3* (Jan. 1929)
241. Amer. Phot. *23* (Jan. 1929) p. 46.
242. Movie Makers *3* (Nov. 1928) p. 728.
243. Phot. Korr. *64* (Nov. and Dec. 1928) pp. 347 and 378.
244. Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 1022.
245. Chem. Zeitung *52* (Mar. 24, 1928) p. 241.
246. Sci. Amer. *140* (May 1929) p. 399.
247. Phot. Korr. *64* (June 1, 1928) p. 183.
248. Sci. Amer. *139* (Aug. 1928) p. 156.
249. Trans. Soc. M. P. Eng. *12* No. 33 (1928) p. 140.
250. Film Daily *46* (Dec. 12, 1928) p. 8.
251. Inst. Rad. Eng. 17 (1929) p. 536.
252. Popular Wireless *13* (June 30, 1928) p. 587.
253. Mot. Pict. News *38* (Oct. 6, 1928) p. 1071.
254. C. F. Jenkins, Trans. Soc. M. P. Eng. 12 No. 36 (1928) p. 915; also Radio News *10* (Nov. 1928) p. 420.
255. Telephone and Telegraph Age *46* (Aug. 16, 1928) p. 363.
256. Rochester Democrat & Chronicle, Jan. 13, 1928.
257. F. Gray, Bell Tel. Labs. Reprint B-301 (Apr. 1928); also F. Gray, Bell Labs. Record *7* (Mar. 1929) p. 276.
258. Radio World *14* (Nov. 3, 1928) p. 14.
259. Radio News *10* (Oct. 1928) p. 320.
260. Brit. Pats. 288,234; 291,029; 292,365; 294,671; 297,078; 299,076; 300,592; Fr. Pats. 633,854; 637,801; 638,092.
261. H. Mueller, Kinotechnik *10* (Sept. 5, 1928) p. 462.
262. Kinotechnik *10* (Dec. 5, 1928) p. 624.
263. L. Fink, Kinotechnik 10 (Nov. 20, 1928) p. 580.
264. Kinotechnik 10 (Aug. 5, 20, 1928) pp. 409 and 432.
265. Kinotechnik 10 (Sept. 20, 1928) p. 483; also Sci. Papers Inst. Phys. Chem. Res. (Tokyo) No. 149 (June 20, 1928) p. 247.
266. Sci. Amer. *139* (Sept. 1928) p. 212.
267. A. M. Jacobs, Photo-Era *61* (Oct. 1928) p. 229.
268. Sci. Amer. *139* (Nov. 1928) p. 423; also Brit. Pats. 273,234 and 289,786.
269. Kinotechnik *9* (Aug. 5, 20, 1927) pp. 397 and 428.
270. Schweiz. Photo-Ztg. *30* (June 1, 1928) p. 194.
271. U. S. Pat. 1,680,619; Brit. Pats. 287,188; 287,388; 292,207; 292,631; 295,643; Fr. Pats. 637,392; 637,878.
272. Licht Bild Bühne *21* (Oct. 6, 1928) p. 19.
273. Brit. Pats. 287,488; 288,290; 289,864; 293,047; 293,048; 293,306; 294,493; 294,579; 295,313; 297,773; 298,242; Fr. Pats. 636,540; 638,372.
274. Phot. Korr. *64* (June 1, 1927) p. 186.
275. U. S. Pats. 1,690,584; 1,696,739; Brit. Pat. 296,422; Ger. Pats. 455,047; 463,392.
276. Trans. Soc. M. P. Eng. *12* No. 33 (1928) p. 140.
277. Z. wiss. Phot. *26* (Oct. 1928) p. 171.

278. Exhib. Herald and Mov. Pict. World *93* Sect. 1 (Nov. 24, 1928) p. 34.

279. U. S. Pats. 1,674,810; 1,675,573; 1,677,310; 1,679,695; 1,685,281; Brit. Pats. 288,146; 300,818; Fr. Pat. 633,305.

280. Filmtechnik *4* (Oct. 13, 1928) p. 407; also Phot. Ind. *26* (Sept. 26, 1928) p. 1002.

281. New Phot. *11* (May 19, 1928) p. 181.

282. Phot. Dealer *42* (Nov. 1928) p. 528.

283. New Phot. *11* (Mar. 5, 1928) p. 556.

284. Movie Makers *3* (Nov. 1928) p. 738; also Filmtechnik *4* (Oct. 27, 1928) p. 427.

285. Movie Makers *3* (Dec. 1928) p. 812; ibid. *4* (Jan. 1929) p. 886; Amat. Films *1* (Dec. 1928) p. 76.

286. Movie Makers *3* (Nov. 1928) p. 739.

287. Movie Makers *3* (Sept. 1928) p. 611.

288. Movie Makers *3* (Aug. 1928) p. 536.

289. Movie Makers *3* (July 1928) p. 477.

290. Phot. Era *60* (May 1928) p. 307; Ed. Screen *7* (June 1928) p. 165.

291. Sci. Amer. *140* (April 1929) p. 354.

292. Movie Makers *3* (Dec. 1928) p. 774.

293. Rev. franc. Phot. *8* (Oct. 15, 1927) p. 301.

294. Brit. Pat. 297,995.

295. U. S. Pat. 1,690,616.

296. Mees, Camera Craft *35* (Sept. 1928) p. 403; also J. Frank. Inst. *207* (Jan. 1929) pp. 1-17; Capstaff and Seymour, Trans. Soc. M. P. Eng. *12* No. 36 (1928) p. 940.

297. E. C. Anthony, Movie Makers *3* (Dec. 1928) p. 771.

298. A. Jaschke, B. J. *75* (Oct. 26, Nov. 2, 1928) pp. 647 and 663.

299. H. Fraenkel, Mot. Pict. News *38* Sect. 1 (Dec. 29, 1928) p. 1925.

300. Mot. Pict. News *39* (Jan. 12, 1929) p. 95.

301. Mot. Pict. News *38* (Dec. 1, 1928) p. 1665.

302. Mot. Pict. *4* No. 6 (1928) p. 6.

303. Mot. Pict. *4* No. 12 (1928) p. 6.

DISCUSSION

MR. RICHARDSON: That report does credit to Mr. Crabtree. One thing I did not hear mentioned, however, and one which is most important in many ways, is that through an improvement very soon to be realized, the heat on the film at the projector aperture, which was working great damage, is to be reduced by a half without any reduction in the light. In fact, according to demonstrations I have witnessed, there is an increase in the light and better general results on the screen and the heat is reduced, so that I have held my hand in the beam of the Peerless spot for three or for seconds before it became uncomfortable.

MR. CRABTREE: We have dealt with heat-absorbing devices in the report. The projector you have in mind was mentioned at our last convention.

MR. HILL: I should like to ask whether the report includes anything on the telegraphone for sound recording. Experiments are being made on recording on a magnetized wire for film.

MR. CRABTREE: Transactions No. 36 give a full discussion by Mr. Taylor in the Open Forum. Nothing further has been published during the past six months, although a lot of people are working on the problem.

REPORT OF CONSTITUTION AND BY-LAWS COMMITTEE

I once made some suggestions which were promptly taken up by the President and I was made chairman of this committee. Our Constitution and by-laws, drawn up some time ago, are combined in one draft of many sections. Some of the committee feel that to conform to modern parliamentary usage, this should be somewhat rearranged, while others would like to see this very much modified. It has been impossible to make more than a report of progress, today, but with your permission, the committee will be glad to submit a report at the next convention which will set the constitution by itself, and the by-laws in regular order, including the amendments recently adopted. By fall, we hope to publish a revised constitution and by-laws, approved by the Board of Governors, with a view to its adoption by the members at the next meeting.

W. C. Hubbard, *Chairman*

REVISION OF SECTION 5 IN CONSTITUTION AND BY-LAWS

Section 5 of the Constitution and By-Laws, which was revised to read as follows, and which was circularized in printed form to members before the Spring Convention, was voted upon and ratified at the business session on Monday, May 6, 1929, of the Spring Convention of the Society of Motion Picture Engineers.

Applications

5. Amended by action at Spring meeting 1929, New York City, N.Y., and made retroactive to October 1, 1928.

All applications for membership or transfers shall be made on blank forms provided for the purpose, and shall be accompanied by the required entrance or transfer fee.

The entrance fee for applicants residing in the United States and Canada shall be $30.00 for admission to the grade of Active Member, and $20.00 for admission to the grade of Associate Member.

The entrance fee for applicants resident in foreign countries, outside of the United States and Canada, shall be $15.00 for admission to the grade of Active Member, and $10.00 for admission to the grade of Associate Member.

The transfer fees from Associate to Active grade shall be the difference between the above mentioned fees, or $10.00 for members resident in the United States and Canada, and $5.00 for members living in foreign countries outside of the United States and Canada.

The annual dues shall be $20.00 for Active Members, and $10.00 for Associate Members, payable on or before Octobr 1 of each year. Current or first year's dues for new members, payable on admission to the Society, shall be prorated on a quarterly basis.

REPORT OF SECRETARY

October 1, 1928 to April 30, 1929

ON OCTOBER 1 of last year, I took over the office of Secretary of the Society. The rapid expansion of our membership during the past six months, and the formation of the London Section have brought larger responsibilities and increased work to the Secretary's office.

At a meeting of the Board of Governors on December 3, 1928, the Board recognized that the demands made on the secretary were heavy, and approved the appointment of an assistant to the secretary. Miss Renwick took this position on January 7, 1929, and has been kept very busy since that time. We have eliminated the delays of the first three months and can now report that Society business is receiving prompt attention.

It is, of course, impossible and unnecessary to outline all of the activities of the Secretary, but the following subjects should be of interest to the members.

New Members

The formation of the London Section, and the work of our committee on membership, with Mr. Cowling as a very active Chairman, have added 88 active members, and 76 associate members to our rolls since October 1, 1928. We have had the following losses in membership during the same period.

Deaths—1.

Resignations—7.

Dropped from rolls—5.

Three associate members have transferred to active membership.

The distribution of our membership indicates the wide spread reputation of our Society.

American members

East, including New York.....246
Middle West, including Chicago..... 57
West, including Los Angeles..... 82

Foreign members

British Isles	64
France	11
Canada	9
Germany	8
India	5
Australia	2
Russia	1
Sweden	1
Japan	1
Holland	1
Switzerland	1
	485

Our total membership to April 30, 1929 is 485 members, including five honorary members, 276 active members and 209 associate members.

In addition, the following applications are under way—16 for active membership, and 13 for associate membership.

Sale of Transactions

A total of 1,134 transactions from October 1, 1928, to April 30, 1929, have been mailed out. 858 transactions were forwarded as a result of direct sale. The remaining 276 were to take care of old and new members who could not be supplied by the printer. Further evidence of foreign interest in our meetings is shown by the following shipments of transactions to foreign countries from this office:

British Isles	125 copies
Germany	84 copies
Japan	38 copies
France	29 copies
Canada	18 copies
India	10 copies
Australia	5 copies
Holland	3 copies
Russia	2 copies
Norway	2 copies
Total	316 copies

Aims and Accomplishments Booklet

We have sent to a list of representative libraries in the United States and Canada, a copy each of the new Aims and Accomplishment book. The list, totaling 228 names, was furnished by Mr. Crabtree.

Since the appointment of an assistant, we have been able to take care of present requirements, and in fact, to assist to some degree, other officers and committee chairmen in handling their routine matters. Much more should be done along this direction as the Society expands. As an experiment, we intend to take over, at Mr. McGuire's urgent request, the publication of the Quarterly Bulletin after this convention.

I do not want to over-emphasize the amount of work and correspondence which is handled by the Secretary, but my experience during the past six months has convinced me that the Society is nearing a point in size and prestige where further organization of the Secretary's office will be advantageous. There is no difficulty in finding plenty to do. The real difficulty lies in proper discrimination between conflicting tasks. In addition, methods which were satisfactory when the Society was small, and every member knew each other, have to be revised to meet our new conditions of greater membership and extended geographical limits. These new conditions place increased demands on the Secretary's office.

R. S. Burnap,
Secretary

REPORT OF THE JOURNAL COMMITTEE

The committee appointed to consider the possibility of publishing a monthly journal, or at least one appearing at regular intervals, is not prepared to submit a formal report; in fact, we had not intended to make any report at this time. At your president's request, however, I will give you some idea of what has been done and what we are doing.

One meeting which was held was unfortunately not attended by all members. The committee is not unanimous in its opinion on the subject. Some are violently opposed, and some are enthusiastically in favor, so I want you to distinctly understand that what I say is not an official report of the committee but what I consider to be the consensus of the opinion of the committee. On the whole, I think the committee is in favor of replacing our Transactions by a monthly journal as soon as we can see our way clear to finance the expense involved.

I believe a journal appearing at regular intervals would be excellent for the Society. We have reached the time when the papers are of sufficient volume to warrant the publication of a journal at monthly intervals. There are many advantages to be gained therefrom. Many communications are of vital interest to the members which do not appear as papers presented to the organization and as long as we are publishing Transactions we can not include them in our Transactions since they are not read and discussed at one of our meetings. I think it highly desirable that we have a publication in which we can publish articles by members, and perhaps non-members, of the Society and things which should appear between conventions. In many cases a man may produce a paper and be desirous of getting prompt publication. It is highly desirable, and I think the majority of the committee feel the same, that we have a journal appearing at regular intervals containing material other than that presented at our own conventions.

The vital thing is can we pay for it and is our income sufficient? We are spending more than 5,000 a year now on publishing our present Transactions.

L. A. Jones, *Chairman*

MR. CRABTREE: The last number cost $2,000, so that on that basis the figure would be $8,000.

MR. JONES: That is high, of course, and perhaps $6,000 would be an average figure for what we are spending annually in publishing our Transactions. We have analyzed the cost of publishing a journal at monthly intervals, taking this data from other similar organizations. One society, quite comparable to this organization and having a membership of 500-600, say the cost of their journal per year is between $12,000 and $15,000. We must see our way clear to get that money, and don't want to advise the Society to take on the publication of the journal without being sure we can carry the financial burden. It would involve hiring an editor. The Society cannot ask one of its members to act as the editor of a journal. It is possible that an editor hired to publish the journal might be able to take on other duties, such as assistant to the secretary or act as assistant to the treasurer.

The committee hopes to meet during the convention and at the fall meeting we may have a definite recommendation, but the committee is doing something and attempting to find out how we can publish a journal which to most of us would be very advantageous.

One other phase of the matter I want to mention. A monthly publication appeals very much more to some people than something appearing at irregular intervals. I think it would assist the Membership Committee and give them something more to sell. A monthly publication will appeal very much more to libraries. Many hesitate to subscribe to proceedings of a society appearing at irregular intervals. I believe that our number of library subscriptions would be increased by 300 or 400 if we were offering a monthly periodical, and taking all things into consideration, it is highly desirable.

The committee feels very strongly that if we publish a journal it must be a strictly technical engineering and scientific journal and must not be allowed to take on the character of anything resembling a trade paper. We must keep the standard high, and if we attempt a journal it must be strictly technical.

MR. MCGUIRE: I don't want to take up a moment of the convention, and it would be unwise to discuss this report, but I was put on the comittee because I am utterly, completely, and absolutely opposed to the Society having its own publication. This is the one thing on which I pose as an expert in the Society. The expense I know; you might as well charge off $15,000 at the start.

President Porter: May I ask your permission, Mr. McGuire: This question of publication is of vital importance to the Society. It needs a great deal more detailed study than it has been given, and there is no possibility of any action being taken before the next convention, when it will come before the body as a whole with further data from the committee, and it is my suggestion that we postpone any further discussion until our next convention, because long discussion here will not affect the result.

Mr. McGuire: That is correct. I merely want to register my objection.

REPORT OF THE MEMBERSHIP COMMITTEE

AT THE Lake Placid Fall meeting of the Society of Motion Picture Engineers in September, 1928, your Membership Committee reported that 130 new members had been accepted and added to the society during the year, making an increase of more than fifty per cent in the membership.

At the same time, we announced that the object of the membership committee was to obtain a total of 1,000 members by the end of 1930. The membership committee takes pleasure in reporting again, the greatest expansion of the Society yet accomplished. In the past six months since the Lake Placid meeting, we have accepted and added to the society over 200 new members. In addition, about 40 applications are pending before the Board of Governors for action. We are thus well on our way toward the goal of 1,000 members.

The Membership Committee takes this opportunity of urging every member to send in the names of all technical workers he knows to be eligible so that the membership committee may extend them a cordial invitation to join the society.

Fifty of the new members are of the recently established London section, the formation of which was accomplished by Dr. Hickman in London, where he spent considerable time last summer discussing the Society's affairs.

Your committee has made a special effort to obtain members in foreign countries, and has been successful in securing members not only in Germany, France, and Italy, but in such far countries as India, and Japan, and Australia.

Particular efforts are being made to extend the S.M.P.E. benefits and membership to the younger technical workers, and quite a large number of the new members are Sound Picture technicians who have been attracted to our Society through our interest in sound picture production.

In conclusion, we feel compelled to remind you that the society has changed. The society of today is not the society of yesterday. It has the same ideals, the same high scientific purpose, but its personnel and its opportunities have undergone an expansion which demands re-adjustment.

Two years ago, we were faced with the choice between remaining a small relatively unknown scientific society or becoming a large internationally known technical organization. We have chosen the latter course; but this choice carries great obligations. To those already in the society, no matter what their standing, it carries the necessity for re-adjustment, to those joining us, it gives the privilege of contributing, to the most progressive movement in the motion picture industry.

We find there are a large number of the younger technical workers in the motion picture industry who feel that the entrance fee and dues are rather high, and we believe that a reduction of the entrance fee should be made as soon as it is shown that finances of the society will permit. The advisability of having the same dues of active and associate members should be considered. There appear no particular reasons for discriminating against active membership.

MEMBERSHIP COMMITTEE

H. T. Cowling, Chairman

J. W. Boyle	M. L. Mistry
E. E. Blake	B. E. Norrish
J. W. Coffman	E. C. Schmitz
J. T. Flanagan	J. L. Spence, Jr.
E. R. Geib	C. M. Williamson
K. C. Hickman	F. C. Zucker

REPORT OF BUSINESS RELATIONS COMMITTEE

YOUR Committee has sent out nearly 200 letters, to approximately 90 of the leading organizations of the country, who are directly or indirectly benefited by the work of our Society. In addition to our letters, Mr. Will H. Hays addressed individually each member of his organization.

Up to the present time, only 17 organizations have responded to our appeal. These have subscribed to a total of 128 annual subscriptions, and one of the firms sent a check for $100.00 in cash, without desiring a consideration therefore. This makes a total of $1,380.00 thus far subscribed.

It is our hope and expectation that there will be some further responses before we consider the appeal concluded. It is obvious from the above that the net returns from the efforts of your Committee will be considerebly in excess of the returns recently received from advertising in the Transactions.

Respectfully submitted,

BUSINESS RELATIONS COMMITTEE

WILLARD B. COOK,

Chairman

REPORT OF THE PROJECTION COMMITTEE

THE Society has seen fit to give official recognition to the importance of motion picture projection and the motion picture projectionist by the appointment of a standing committee on projection.

The personnel of the committee is widely scattered, and several of the members are subject to call to various parts of the country on business of their companies at any moment. For this reason the chairman had to abandon his original idea of having one or two meetings of the committee before this report was made up; for this reason, the report is based entirely upon correspondence, plus such personal touch as it was possible for the chairman to have with the very busy and somewhat overworked men within his physical reach. And finally the writing of the report fell very suddenly and unexpectedly upon one member at practically the last moment.

The foregoing is set forth in order that you may understand, and in the hope that you will excuse the admitted incompleteness of the report. Your committee by no means regards it as a final report, and realizes that the most gracious reception it can hope for is to have the report accepted as an indication of progress, and referred back to the committee for further work in the interim between now and the fall convention.

After due deliberation, and after consultation with the various members of the committee, it was decided to concentrate our first efforts upon the compilation of a statement of what constitutes the fundamenal requirements of the modern projection room. Our decision in this matter was based upon the fact that, though it is true some material has appeared in the trade press as well as that in the Bluebook of Projection, there is not available to the architect (except at the expense of a great deal of time and trouble to himself), a complete, correlated and comprehensive treatise on the requirements of the modern projection room and the fundamental requirements which must be satisfied if results which can adjudged acceptable, according to modern standards, are to be obtained and maintained.

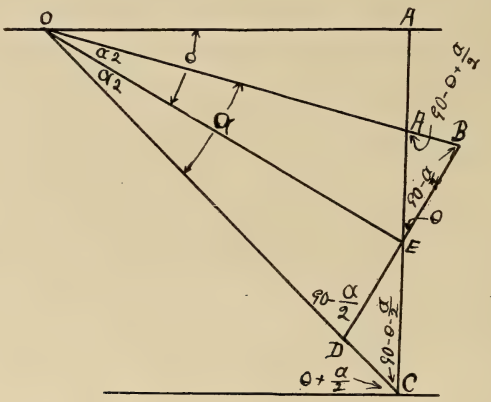
There is great need for such a treatise. The lack of authori-

tative standards to which architects may refer, has resulted in a very large number of designs which are hopelessly inadequate for modern motion picture and sound picture projection.

Your committee therefore selected as the subject for its first report *The Fundamental Requirements of the Modern Theatre Projection Room.* The various requirements will be set forth in their order, together with such recommendations as may seem proper.

Location

It is essential to good projection that the projection room location be such that there will be no objectionable distortion of



the screen image due to the projection angle being excessive, and furthermore it is essential that the projection distance and picture size be so related as to require the use of a lens of such focal length as to combine critical definition over the entire field with reasonable optical efficiency. Your committee realizes that the great variation in theatre auditorium conditions demands considerable elasticity in the matter of projection room location, and therefore recommends:

1. That the relationship between picture size and projection distance be such as to require a projection lens of not less than four and one-half inches, nor more than seven and one-half inches, equivalent focus.

2. That within this range of lenses the projection angle be as nearly zero as is practicable and in no case to exceed seventeen degrees.

The recommendation as to the equivulent focus of the projection lens is based upon the observation of the members of your committee. The decision in the matter of the limiting angle was reached through a mathematical analysis of the situation.

Let us refer to figure 1, below O is the optical center of the projection lens; θ is the projection angle; α is the vertical angle of the divergency of the light beam; AC the height of the projected picture; and BD is the height of an undistorted picture projected the same distange (OE) by the same lens.

Realizing that for a given projection angle, the distortion would be more serious with short focus lenses than with those of long equivalent focus, your committee sought to express the increase in height, of the projected picture due to the projection angle, in terms of this angle and the angle of divergency of the light beam; that is, to express the ratio AC : BD as a function of θ and α.

$$\frac{AC}{BD} = \frac{AE+EC}{BE+ED}$$

Now $AE \sin \alpha/2 :: OE : \sin (90+\theta-\alpha/2)$.

Therfeore $AE = OE \sin \alpha/2 \div \sin (90+\theta-\alpha/2)$.

And $EC : \sin \alpha/2 :: OE : \sin (90-\theta-\alpha/2)$.

Therefore $EC = OE \sin \alpha/2 \div \sin (90-\theta-\alpha/2)$.

Also $BE+ED = 2OE \tan \alpha/2$.

Then
$$\frac{AC}{BD} = \frac{\dfrac{OE \sin \alpha/2}{\sin (90+\theta-\alpha/2)} + \dfrac{OE \sin \alpha/2}{\sin (90-\theta-\alpha/2)}}{2OE \tan \alpha/2}$$

$$= \frac{OE \sin \alpha/2}{2OE \tan \alpha/2 \sin (90+\theta-\alpha/2)} + \frac{OE \sin \alpha/2}{2OE \tan \alpha/2 \sin (90-\theta-\alpha/2)}$$

$$= \frac{\cos \alpha/2}{2 \sin 90+(\theta-\alpha/2)} + \frac{\cos \alpha/2}{2 \sin 90-(\theta+\alpha/2)}$$

$$= \frac{\cos \alpha/2}{2 \cos (\theta+\alpha/2)} + \frac{\cos \alpha/2}{2 \cos (\theta-\alpha/2)}$$

$$\frac{AC}{BD}=\frac{\cos\alpha/2}{2(\cos\theta\cos\alpha/2+\sin\theta\sin\alpha/2)}+\frac{\cos\alpha/2}{2(\cos\theta\cos\alpha/2-\sin\theta\sin\alpha/2)}$$

$$=\frac{\cos\theta\cos^2\alpha/2}{\cos^2\theta\cos^2\alpha/2-\sin^2\theta\sin^2\alpha/2}$$

Inverting and simplifying

$$\frac{BD}{AC}=\cos\theta-\frac{\sin^2\theta}{\cos\theta}\tan^2\alpha/2.$$

Now the maximum permissible amount of distortion is a matter on which there seems to be considerable range of opinion. Your committee feels that in recommending 5% as the maximum permissible increase in picture height, it is erring on the side of laxity rather on that of rigidity, and is particularly anxious to hear discussion of this matter by the Society.

Proceeding for the moment on the basis of 5%:

$$\cos\theta-\frac{\sin^2\theta}{\cos\theta}\tan^2\alpha/2=0.9524$$

and

$$\cos^2\theta-\sin^2\theta\tan^2\alpha/2=0.9524\cos\theta$$

$$\cos^2\theta-\tan^2\alpha/2+\cos\theta\tan^2\alpha/2=0.9524\cos\theta$$

$$\sec^2\alpha/2\cos^2\theta-0.9524\cos\theta-\tan^2\alpha/2=0.$$

This puts the equation in the quadratic form, and the solution for cosine is of course

$$\cos\theta=\frac{0.9524\pm\sqrt{0.9524^2+4\sec^2\alpha/2\tan^2\alpha/2}}{2\sec^2\alpha/2}.$$

Taking account of the minus sign before the $\sqrt{}$ results in imaginary values so only the positive sign will be considered. Calculations (by 10″ slide rule) are tabulated below thru the range of objective lenses recommended in this report.

Lens E.F.	BD	tan 0(/2	tan ²0(/2	sec ²0(/2	2 sec ²0(/2	4 sec ²0(/2 tan ²0(/2
4	17.0	0.085	0.00722	1.00722	2.01444	0.0290
5	13.6	0.068	0.00463	1.00463	2.00926	0.0186
6	11.3	0.0565	0.00319	1.00319	2.00638	0.01285
7	9.7	0.0485	0.00235	1.00235	2.00470	0.00942
8	8.5	0.0425	0.00180	1.00180	2.00360	0.00721

E.F.	Log Cos θ	θ
4	9.97924−10	17° 35′
5	9.97901−10	17° 40′
6	9.97893−10	17° 42′
7	9.97870−10	17° 44′
8	9.97887−10	17° 44′+

Thus it becomes apparent that thru the range of focal lengths recommended, the percentage of increase in picture height is practically influenced only by the projection angle, the percentage being approximately equal to the "secant minus one" of the projection angle. The present standards of the Society set the maximum projection angle at 12°, corresponding to an increase in picture height of about 2.5%. Thus we see that the distortion has doubled for a 40% increase in projection angle, and it becomes exceedingly apparent that it is a serious thing to add even as much as two degrees to the projection angle when designing a theatre; this should never be done except for the most urgent reasons, and never merely to obtain architectural symmetry in a part of the theatre which the audience seldom sees.

The sidewise location of the projection equipment should be so graded as to favor those projectors which have to produce the most sharply defined images. This consideration should place the motion picture projectors as closely as possible to the center line; but one must also take into consideration the increasing practice of simultaneous operation of stereopticon, effect projector and motion picture projector in order to secure special and very beautiful effects; this loses much of its beauty if the images are not very closely matched. These considerations have led your committee to classify its recommendations regarding transverse location of equipment as follows.

For the installation of either two or three motion picture projectors, stereo and effect projector, with or without spot lamps and flood projector, we recommend that the axis of projection of the motion picture projector nearest the stereo be at right angles to the horizontal axis of the screen.

For installations of three motion picture projectors, with or without spot lamps, we recommend that the axis of projection of

the center projector be at right angles to the horizontal axis of the screen.

For installations comprising two motion picture projectors only (or with the addition of spot lamps), we recommend that their axis of projection make equal and opposite angles with the horizontal axis of the screen.

In certain special cases it will be highly desirable to locate the projection room in (not on) the front of the balcony. In such cases a careful check of the balcony construction should be made to insure there being no shifting of the axis of projection as the balcony fills and empties. Ventilation of a projection room so located, becomes more of a problem than in the case of the more common locations; but it is of much greater importance. This will be treated later.

Dimensions

(Size of Room)

The size of the room may vary rather widely, according to the amount of equipment it is intended to install; but in width, the wise exhibitor will make ample allowance for possible additional equipment. This is just as important as it is to install wiring sufficiently in excess of immediate needs to take care of demands which may be made in the future. It is an expensive thing to be obliged to rebuild the room, or to tear out the wiring in order to put in larger wires. At the time of construction, neither a bit of added space or somewhat larger wires requires any very serious additional outlay.

In the matter of front to back depth, there must be sufficient space to leave at least a thirty six (36′) inch passageway clear of everything between the lamphouse controls and whatever may be against the rear wall. This amount of space is necessary for the comfortable handling of the equipment. The necessary depth may be ascertained by the architect by taking the over-all projector length of the modern projector, setting it in horizontal position at sixty-three inches, adding one foot to that measurement (or eighteen inches, if the projection angle will be a very heavy one), and thirty-six inches plus the depth of whatever equipment it may be intended to place back of the projectors against the rear wall. In fact, it is best to allow three feet for the latter, whether the present intent is to install anything there or not; this would make a total

of five feet three inches, plus six feet, or eleven feet three inches as the minimum front to back depth.

In the matter of ceiling, seven and one half feet should be the absolute minimum. In excess of that, the more the better.

As to width, that is a mooted question. But there must, for the best results, be ample space, between projector (both motion picture and other sorts) to permit of free movement. Where the projection distance and picture size is such that a sharp picture may be obtained all over the screen with a four and one-half foot spacing lens (center to lens center of motion picture projectors) that distance should be the minimum. However, conditions may be such that this would be impractical; but under any condition there must be no less than a three and one-half foot spacing, lens center to lens center. In fact, this may be the rule under all conditions for all but the motion picture projectors.

Of course space must be allowed for the amplifying panel etc., which would be done in the future, whether sound is to be immediately installed or not.

This is not designed to be anything more than a general discussion of dimensions. Your committee hopes, in the future, to take that item up in more complete form.

Construction

Your committee conceives the fundamental requirements of projection room construction to be:

(a) The room must be thoroughly fireproof.

(b) It must be as nearly as possible sound proof, because of the fact that in addition to the unavoidable noise incidental to machinery in operation, we now have added the necessity for conversation between the augmented projection staff, the additional noise created by certain types of sound equipment, and rising above this, the output of the monitor horn.

(c) The material should have as low specific heat as possible to prevent its becoming a "storage reservoir" for heat.

(d) In some cases the weight will have to be considered if the building structure supporting the projection room is not amply strong. In this connection your committee desires, without recommendation, to point out that for wall construction, hollow tile eight inches or more in thickness set in rich mortar strongly tempered

with cement, and covered with a smooth, hard finish plaster fulfills all of the above requirements better than any other material.

The Floor Slab should support the projection equipment without the slightest vibration, and be of a material which will not wear away and form dirt or dust. We therefore recommend that the floor slab be of concrete of approved mixture, not less than six inches thick, covered with an approved top dressing of cement and covered with battleship linoleum or rubber tile firmly cemented to the floor slab. This linoleum or tile should be laid after all plastering, painting, wiring, etc., has been completed, but before any of the projection equipment has been installed. Before the projection equipment is installed the linoleum should be thoroughly cleaned and waxed to prevent it absorbing oil from the machinery. Incalculable damage has been done to projection machinery and to sound film by the fine dust rising from uncovered projection room floors; such stone floors belong to the stone age, and have no place in the modern projection room. Aside from their injurious effect upon equipment they have the effect of unduly fatiguing those who must stand constantly upon them, thus reducing their alertness and lowering their efficiency, two things which no theatre can afford to have happen to its projection staff.

Conduits, Outlets and Anchors

In the modern projection room there is the necessity for so many electrical circuits that it is both unsightly and highly impractical to run the conduits on the surface. They must be built into the walls, floor and ceiling. It is also essential that all electrical cal outlet boxes, ventilation ducts, anchor bolts, etc., be exactly located prior to the construction of the room, and that the faces of all outlets be located flush with the surface except in special cases where there is good reason for doing otherwise.

Rewind Room

This room is for storing, rewinding, inspecting, repairing and assembling film. It should open directly into the main projection room, and if possible into the screening room as well. Every possible precaution in design, finish, equipment and ventilation to make this room clean and dust-free is justifiable when one considers the delicate nature of the sound track on modern sound film. Size will vary with conditions, but your committee regards eight feet by ten feet

as representing the minimum acceptable dimensions unless storage cabinets for film and records are built into the walls of the room.

Battery Room

If battery operated, sound synchronizing equipment is to be installed, there must be a thoroughly ventilated room, sufficiently large to accommodate these batteries and their charging equipment, conveniently adjacent to the main projection room. Batteries, in charging, give off gas and vapors which are inflammable and have a corrosive action on human tissues and on most metals. Hence the absolute necessity for ventilation. This room should be at least six feet wide by eight feet long with suitable shelving for the batteries.

Motor Generator Room

In modern practice, it is fundamentally essential that there be a well ventilated room adjacent to the main projection room for housing the resistance units or the motor generator, whichever be employed. Here, as in the projection room, construction should be fireproof, and all conduit etc. should be built into the walls, floor and ceiling—not run on the surface. Size will vary greatly with the type of installation. The fundamental requirement is that ample space and light be provided around each unit. In certain types of sound equipment, a motor generator unit replaces almost all of the storage batteries. In such cases, more motor generator space must be provided, but the battery room can be reduced to a ventilated cabinet in the motor generator room.

Wash Room

It is fundamentally essential, regardless of the type, class or size of theatre, that, adjacent to, and opening directly into, the main projection room, there be a room of suitable dimensions equipped with wash basin and toilet, with running water. To this equipment, many progressive exhibitors have added a shower bath which, while not a fundamental necessity, is a most excellent dividend paying equipment, especially in warmer climates. The wash room is an absolute necessity now that sound film has arrived, because dirty, oily hands are mortal enemies to sound film or disc records.

Observation Ports And Fire Shutters

The size and position of all ports are matters governed largely by local conditions. The main factors to be considered are type of

equipment, size of theatre and projection angle. Fundamentally, port requirements are very simple. The projection port should permit the projection of an image to any part of the theatre required of that particular projector. In the case of the spot-lamps, flood-lights, stereopticon, and effect projectors, and at least one motion picture projector, this will include the entire front of the auditorium. The observation port should permit the projectionist to have full view of this area from normal operating position beside the projector in question. Satisfying these requirements is a simple matter, but calls for careful checking of all dimensions. In some cases it will be necessary to cut the ports with their walls flaring outwards if the projection room walls be excessively thick. The fundamental requirement of port shutters is that they surely, quickly and quietly close all ports within a few seconds of the inception of any film fire. We respectfully recommend the system of shutter suspension and semi-automatic control adopted by the state of Pennsylvania, or that employed by the Chicago division of Public Theatres Inc.

Ventilation

Projection room ventilation has two separate and distinct functions. First, it must exhaust all of the hot gases from the arcs, remove foul air from the room, and maintain comfortable temperature at all seasons of the year. Second, it must be capable of exhausting all fumes from burning film, in the event of a film fire, as fast as they are formed.

The first requirement is best met by two independent systems: one for the room in general; the other, directly connected to the lamp houses. In the cases of the spot-lamps, stereopticon and effect projectors, this direct connection may not be practical; but for the motion picture projectors and the floodlights it is absolutely necessary. The room ventilation system should be capable of making a complete change of air in three minutes. The lamphouse ventilation system should be capable of keeping the temperature of the air in the vent pipe eight inches above the top of the lamphouse at not more than 350 degrees F.

It is very doubtful if, for taking care of the fumes from a film fire, it would be unreasonable to recommend a system having a capacity of 5,000 cubic feet per minute. It should be capable of maintaining the barometric pressure in the projection room during

the fire substantially below that of the auditorium so that none of the inevitable crevices will exude any traces of smoke or flame.

Your committee realizes that this section of the report is far from complete, and intends to go more thoroughly into the matter of ventilation in the time between now and the next meeting of the Society, treating the matter somewhat in the manner of stack loss problems in power plant engineering.

Now after all bare, physical, fundamental requirements have been taken care of, there still remains a vitally important one which is often overlooked—though it is just as fundamental as those of a more definite nature. The audience sees the picture and other projected effects seated amid the most finished and luxurious surroundings that architects and artists can create. Now if the projectionist views the same picture and effects framed by a dirty, oil spattered unplastered wall festooned with a serpentine maze of conduit etc., can his mental attitude be the same, can his standards of judgment be as high as those of the audience, no matter how conscientious he may be? Never! This psychological stimulus of fine surroundings is a truly mighty force. It is ample justification for the best finished projection suites that any architect can conceive. The man who is not susceptive and responsible to these things has no place in the modern projection room.

F. H. Richardson, *Chairman*

Arthur H. Gray	J. H. Kurlander
Chauncey L. Greene	Harry Rubin
Herbert Griffin	Mark S. Swoat
Lester B. Isaac	

REPORT OF THE LONDON SECTION

SIMON ROWSON*

PRESIDENT and Gentlemen:

I want first to express my pleasure at being able to be among you today. When I heard of the date fixed for the convention, I tried to arrange my business visit so that I could be present, and I want therefore to say at once that I am glad on behalf of the Section I have the honor to represent—London—to be with you today, and take part in your deliberations.

Our section is a junior one, but I believe it will turn out to be a very important one. Importance in this department of our activities is measured not so much by numbers as by its power to influence views and thoughts upon the technical matters connected with our industry. I feel that while on the technical side of your industry you have associated a good many British technicians from our universities and colleges, there are left behind in Britian quite a number of other scientists capable of making contributions of international value in this business, and I think nothing is more significant than the tone and character of the deliberations since the Section was founded the early part of the year. You have not had the papers in your Transactions, but you will be interested in the kind of papers read up to now.

We opened at the beginning of the year with a paper by C. F. Elwell, who summarized the different sound recording and reproducing systems from a purely technical point of view, and it is to his credit and that of the Society that in preparing a very technical survey of this branch of the industry he never tried to push the particular type of mechanism with which he was interested. He was interested with the DeForest outfit and is a technician, high-class physicist, and engineer, but he never, although he is a good commercial man, tried to push his own ware. He introduced that scientific spirit which we are so anxious to keep. The second paper dealt with Camera Mechanism and was by Mr. Newman, one of the pioneers of cameras about 25 to 30 years ago and now associated particularly with the Newman-Sinclair camera. His paper proved

* London, England.

to be most excellent and was found most intriguing in producing questions of wide range and variety. The third paper was by Mr. Schwarz of the Elstree Studios on trick lenses, which provoked considerable interest and discussion, and he brought with him an armoury of the lenses to demonstrate. It was enormously interesting to everybody connected with studio work. Since I have been away another paper has been fixed by Mr. Sunde on the acoustic problems connected with the camera and the studio. That is the character of the people who have read papers, and I can assure you that when you read them in the Transactions, you will feel that we have attempted to make real contributions to the technical branch of this great industry. Mr. Roy Pomeroy and Mr. Rosher, now in England, have also promised to contribute at an early date.

I am pleased to say, however, that not only has the quality of the work so far accomplished been high, and from that point of view its influence is great, but the number who have become members has, I think, been satisfactory. We started with a very small membership of perhaps under 30. Every meeting has been attended by 50-70 people, and every meeting has resulted in additions to our membership, so that at present we have about 80, and by the end of the year we hope to turn the century, and I think that will be a very satisfactory start.

We are trying to conform to the rules laid down from this side, where we realize headquarters are, but I hope you will also realize that it is not always wise to enforce your rules too strictly in a country so far away as England. We have the right feeling and the right spirit, and we will not let you down, but don't try and insist too much on regulations and rules which are not vitally essential to the successful working of the Society if we feel that some small modifiations will be better adapted to our own particular requirements. I am pleased to say that the grade of membership is very high, and we have not a few of the leading executives of the bigger companies who have willingly accepted my invitation to become members of the Society and have shown they believe in the Society. They have encouraged many of their own technical staff on the same basis.

I think you will be very proud of the child which you have given birth to in England.

THE WEST COAST

ELMER RICHARDSON*

THE Pacific Coast Section met a few nights before we came East and extends you the greetings of the Section. A year ago when you were there, you filled us with enthusiasm and established a Section. Unfortunately, we are most of us engaged in the productive end of the business and that involves encroachment upon our evening time, so that it isn't so easy to establish a group. The attendance is usually about 35, the meetings taking the nature of a dinner, followed by a very interesting discussion. We have never yet been able to get the boys to be dignified at the meetings, which partake more of the nature of a round-table, dealing with the matter in hand. We have plenty of problems which are unsolved and difficult to solve. Before the program is over here, you may be able to deal with the problems which have been brought to our attention. Mr. Rackett is here and we are looking for Mr. Ball and our old friend Kelley of many years' standing in the business. These boys represent the Coast.

One charge was given me, which is very vital to us: We wish to extend an invitation to the Society of Motion Picture Engineers to go to Hollywood for the next general meeting, and I don't want any action on it at all today, but we wish to have you there and could make the meetings interesting and valuable to you.

I bring the greetings of the West Coast at this time.

PRESIDENT PORTER: We certainly appreciate the invitation to come again to the West Coast. After what the boys did for us out there a year ago, it seems to me a good deal to invite us again. I am glad you did, and I am sure your invitation will be given very careful consideration. We are glad you are here and we wish more of you could meet with us.

* Mole-Richardson, Inc., Hollywood, Calif.

TALKING PICTURES AND THE PUBLIC

WARREN NOLAN*

THE old road has been electrified and it is not, paradoxically, as easy to travel as it was when steam was the rule. With the dawn really coming up like thunder and with ham and eggs sizzling on the Transvox screen of the Roxy, the press agent has his troubles. He is asked,—and the answer must be ready,—"Was that really Rin-Tin-Tin that barked?" He coins names like "talkies", "audible cinema" and "non-sinks", and he does not always pick the term that is most descriptive. He must decide whether to publicize the fact that those swords didn't clash in the reconstructed palace of Louis but that Hugo Reisenfeld's musicians tapped some teacups with spoons inside the Trinity Baptist Church in Camden, N. J. He must take the blame for making audiences conscious of mechanical contrivances while they are seeing and hearing productions that aim to achieve an emotional effect; it is undoubtedly true that in the magnificent job of publicizing sound devices publicity departments went beyond the life lines and planted the whirling discs and the tiny sound tracks in the mind's eye of every moviegoer.

Our English cousins tooks the infant to the font and sprinkled the title "audible cinema" on the lusty one. That's a contradiction in terms. It has been pointed out by Faure, Grierson, Reinhardt, Chaplin and others who have taken the motion picture seriously as an individual art form that the term "cinema" is visual in its connotations, that the essence of cinema is visual expression of drama in photographed movement, to the exclusion of the spoken word. Cinema made audible is not, then, cinema at all. We shall have to coin some phrase that may be passed on to the public as accurately descriptive of the new form. As press agents accept facts as they they are and do not idealistically create Utopias, I consider the present all-talking production schedules of all major film companies as a certain indication that we shall have but one form within two years: the legitimate recreation of actuality, the simulation of a reflection of life, this to result from fusion of sight and sound. I think that "Alibi" and "Broadway Melody", in which people talk when they

* United Artists Corp., New York, N. Y.

would talk and not whenever it seems necessary to demonstrate the wonder of science, come closest to the new form. There will be visual action, and there must be visual action because still life won't hold anybody's attention for two hours unless that person is so highly cultivated that he can view photographed beauty, a single scene, for hours. That, literally, is the art gallery's contribution. "Talking pictures" is probably the best term yet devised, because the illusion achieved is one of a reflection that emits sounds that are electrical echoes of human speech.

There has been, for one year, and there will be, for at least two years more, certain difficulties in publicizing sound. As for production, I don't think that technical tricks should be told about sound any more than they are now revealed in the case of photography. Of course it is an age of exposes, an age in which aviators and explorers sign contracts to tell the readers of The New York *Times* how they did it even before they take off to do it, in which *The American Mercury's* influence on other magazines is so apparent in the "debunking" contents of all pubications, even our fan magazines that formerly fed their readers the stuff from which pipe dreams are made. But the film, even the talking picture, depends for achievement of its effects on illusion. That illusion ought to be maintained out of consideration for the audience. This is difficult, from the publicity man's standpoint, because our better newspapers have gone scientific so completely that two technical terms will land a story on page one in place of the widows-and-orphans yarn of the pre-war days. I am trying to tell the Society of Motion Picture Engineers that the individual achievements of its members, when they endanger the illusion of a darkened theatre, should not be publicized. It is like listening to DePachman playing Chopin and thinking all the while of the Baldwin or Steinway publicity about the quality of the wood and the arrangement of the keyboard. Mechanics are an auxiliary, an aid to an emotional effect.

Every publicity man knows that the best publicity an actor can have is his own performance on the screen, for that is direct, personal in its projection to the mind of the audience, and it causes praise to be talked by admirers. The gentlemen in charge of projection of sound pictures,—to say nothing of those who record them,—have been constituted individual showmen by this new form of presentation. They have been given power, and they have been given

responsibility. Timing and tone are in their hands, and artists on the screen and audiences in the seats are at their mercy. One or two distinctly lamentable demonstrations of carelessness at most inopportune times seem to show that rehearsals such as stage producers employ are not attempted with talking pictures. With the performance its own best press agent and with the public judging that performance, it becomes important that motion picture engineers develop appreciation of the significance of publicity. The public only gets an impression, it never penetrates to causes.

The public retains some skepticism about talking pictures because it has always been a Thomas as far as show business is concerned and because there has been inferentially misleading information handed to it in several isolated instances that have undermined the general confidence. The term "Sound Picture" has caused tremendous confusion; it should be displaced by a line, "With Synchronized Musical Score". The kick-back is on the gentlemen who misled by inference, for Patrons feel Barnum is charging them a dime to see the egress once more and they resent it. Publicity and advertising on all pictures should state exactly and explicity how much dialog there is in a picture. The term "Part-Talking" is used in the trade but I have not seen it used to the public. "With Sound" is like a tail stuck on a paper donkey; the traps player in Camden clicks the hoofbeats just like a drummer in the theatre's pits. Publicity should be educational in its effect, and press agents are professors in the sense that they spread knowledge of a particular subject to many people. I don't know any editors who have learned to accept the teachings as gospel, but nothing will be done to remove editorial prejudice against press agents if there is incorrect information or inferentially misleading information distributed about the talking in pictures.

When the late Rudolph Valentino was dying, it was part of my job to appease the demands of the press. This meant the boys had to be told why they couldn't carry their cameras into sick rooms and take pictures of all dying patients, that doctors had to be predisposed to recognize the over-anxiety on the part of the reporters and to give them bulletins, and so on. Well, I learned one day that Valentino had virtually no chance of surviving. That night I was asleep and the telephone rang, out at my home. It was nearly three o'clock in the morning. A tabloid's managing editor was on the

phone, and he made no apology for waking up the press agent nor for the insult in his question.

"Say," he asked, "we got a hunch this Valentino ain't sick at all. We hear it's all a gag, just a publicity stunt. What about it?"

It so happens that Valentino died about nine hours later. I offer the incident as evidence of the skepticism in the minds of some editors, and the necessity for bending over backwards in passing out the truth about Rin-Tin-Tin and other actors, and about the contents of talking pictures. This publicity, I repeat, will be necessary for another year or so. Then the sound-and-sight medium will have taken definite form, it will have been christened, and the vaccination by the victrola needle will undoubtedly make the Infanta of America's industries immune to all the ills that flesh is heir to.

DISCUSSION

MR. RICHARDSON: At one point Mr. Nolan, in speaking of the new synchronization device said that the operator would throw it out to prove how wonderful science is. I want to say to Mr. Nolan that as long as writers and others talk about machine operators that is what is likely to happen. Motion picture projectionalists, however, don't do things that way!

MR. NOLAN: I don't know the name of the gentleman, but he embarrasses me by a lack of a sense of humor (laughter). I could say a great deal about some projectionists who caused us a great deal of embarrassment one evening.

THE MOTION PICTURE CAMERA IN SOUND PICTURES

A. S. Howell* and J. A. Dubray.*

Part One:—Silencing the Motion Pictures Camera.

THE necessity of eliminating all extraneous noises in sound recording Cinematographic work is self evident and too well known to warrant the entering into any discussion on it.

It is also well known that the elimination of such disturbing noises is of much greater importance when scenes are taken within the studio stage than when the work is conducted in outdoor locations.

The problems involved in the building of sound-proof stages, in the damping of the stages and sets, a study of their characteristics, defects and remedies as well as a study of ground noises which can proceed from the film itself and its processing have been presented to this Society at the last two conventions, awakening a great deal of well justified interest.

It is the intention of the authors of this paper to briefly describe the efforts expended in eliminating the mechanical noises produced by the motion pictures camera.

Previous to the advent of sound pictures, the motion pictures camera was devised and constructed with a reasonable disregard of the mechanical noises produced by the rather complicated operation of the instrument.

With the advent of Sound Pictures, these noises have relegated the Cinematographer and his apparatus in a sound-proof booth imposing upon him a number of serious limitations which conflict with the freedom of action necessary for obtaining the fine photographic results which have characterized modern motion pictures productions.

The necessity of eliminating the camera noises was immediately apparent to all interested in the new Art and engaged the immediate attention of camera manufacturers and of the Engineers responsible for the developments of the instrument.

* Bell and Howell Co., Chicago, Ill.

The pressure of commercial demand forced them, however, to conduct the necessary investigation in an extremely rapid manner so that the camera Engineers were called to the rescue with the same urgency in which a surgeon would be called to perform an urgent operation upon which depends the very life of a patient.

It was necessary indeed to make a complete diagnosis of the instrument, to conduct, so to speak, a stethoscopic examination of the vitals of the camera in order to locate the causes of the disturbances and prescribe their remedies.

The rapid but extremely careful and dispassionate examination, brought forth the necessity of departing from some principles of construction which were considered fundamental to the good functioning of the motion pictures camera.

On the other hand, sound synchronized pictures eliminated the possibility of "cranking" the camera by hand and the introduction of a motor drive permitted the mechanical engineers to attack the problems inherent to the silencing of the apparatus with an entirely new conception of the heretofore considered essential attribute of smoothness of running.

This new condition permitted the substitution of all ball-bearings existing in the camera for solid bronze and hardened steel bearings so adjusted that all clearances and tolerances were reduced to a minimum.

The lubrication of the solid bearings presented new problems insofar as the apparatus is called to perform under unusually trying conditions. Provision has been made in order to render these parts readily accessible at any time and although it is true that the lubricating of the silenced camera demands more attention and greater constancy than the regular camera, it can be performed with perfect ease and only demands a normal amount of care.

The noises peculiar to the enmeshing of metal gears have been eliminated by alternating them with formica gears.

The gears connecting the main drive shaft and the intermittent mechanism have been cut spirally so that three teeth are constantly enmeshed, thus giving assurance of perfect smoothness in running.

An extremely interesting problem was brought forth by the necessity of eliminating the noises proceeding from the rewinding of the film in the take-up section of the magazines.

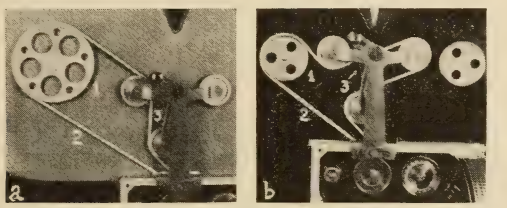
The take-up of film was happily solved from the early days of Cinematography by the use of a spring belt connecting the drive movement of the camera with the take-up pulley of the magazine.

This belt was kept sufficiently loose so as to avoid an excessive tension, and sufficiently taut to assure an easy winding of the film.

The spring belt would slide and skip over the magazine pulley, whenever the speed of the latter was reduced by the increase in size of the roll of film being rewound in the magazine.

For a number of years this arrangement gave perfectly satisfactory results and the noises produced by the skipping of the belt as well as those produced by the joint of the belt when hitting the take-up pulley, were considered as unavoidable and of very little consequence.

These take-up noises were to be completely eliminated and after much study and experimentation, an endless fabric belt together with a new belt-tension equalizing attachment, which automatically secured the proper tension and uniform take-up of the exposed film in the magazine, were adopted.



BELT TENSION EQUALIZING ATTACHMENT

a ATTACHMENT ADAPTED TO A 1000' MAGAZINE
b ATTACHMENT ADAPTED TO A 400' MAGAZINE
1 MAGAZINE TAKE-UP PULLEYS
2 FABRIC ENDLESS BELT
3 BELT TENSION EQUALIZING SPRING

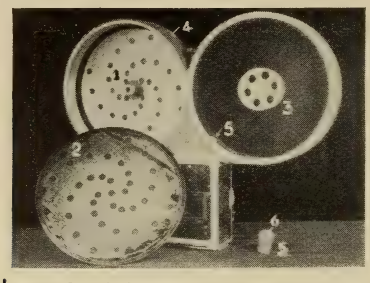
FIGURE 1. Belt-tension equalizing attachment for camera magazines.

Figure 1 shows this arrangement and its adaptation to either a magazine having a capacity of 1000 feet or to one holding 400 feet.

The investigation conducted by the Bell & Howell Engineers, proved that the film magazines themselves were responsible for the transmitting and accentuating of noises or vibrations produced by the camera mechanism, the elimination of which was essential.

The drumming effect which was due to the shape and hollowness of the magazines, was eliminated by drilling their back and cover with numerous holes in spiral formation and by covering them with a one quarter of an inch thick layer of spongy rubber.

Figure 2 shows the position of the holes in the back of the magazine from which the felt lining has been removed and of those in the cover from which the rubber covering has also been removed.



1000' SILENCED FILM MAGAZINE

1 HOLES DRILLED IN BACK OF MAGAZINE FROM WHICH LINING HAS BEEN REMOVED
2 MAGAZINE COVER FROM WHICH RUBBER COVERING HAS BEEN REMOVED
3 3 INCH SPOOL
4 OUTER RUBBER COVERING
5 FILM ROLLER
6 OILLESS BEARING OF FILM ROLLER

FIGURE 2. 1,000′ Silenced Film Magazine.

The spiral formation has been adopted after conclusive experimentation proved that the vibrations of the camera mechanism were completely interrupted by these orifices so disposed, at the moment they reached the large surfaces of the magazine. These surfaces acted, previous to their alterations, in a manner similar to that of a vibrating diaphragm.

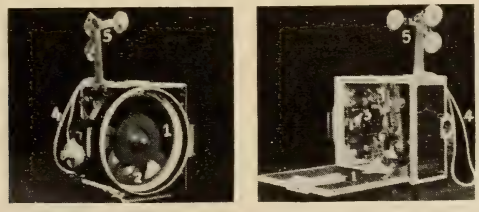
The magazines have also been equipped with especially designed rollers and hubs with oilless solid bearings which are made with painstaking care and accuracy and which are absolutely free from the noises previously inherent to these units.

To further insure the suppression and dampening of any residual noises, the interior of the camera and the shutter blades have been lined with a sound absorbing felt.

Figure 3 shows two views of the camera, one with the lens turret and front plate removed, showing the main formica gear and shutter

and the other with the camera door open to show the intermittent movement and the felt linings in the camera door.

The same care taken in disposing of the camera noises in the above enumerated major parts of the mechanism, has been displayed in the elimination of noises produced by parts of the camera which although less accessible and seemingly of less importance were nevertheless to be taken into serious account.



CAMERA EQUIPPED FOR SOUND WORK WITH TURRET FRONT PLATE REMOVED

CAMERA EQUIPPED FOR SOUND WORK WITH HIGH-SPEED MOVEMENT IN POSITION

1 FELT LINING ON CAMERA DOOR AND SHUTTER BLADES
2 FORMICA GEAR
3 CHECK PAWL SUPER-SPEED MECHANISM
4 FABRIC ENDLESS BELT
5 BELT TENSION EQUALIZING ATTACHMENT

FIGURE 3. Two views of the B. & H. motion pictures camera equipped for sound work.

The intermittent movement of the camera, due to the complexity of the cycle of operations which it is called to perform, suggested immediate and more radical alterations which led to the designing of an entirely new mechanism which is presented in the second part of this paper.

The extremely urgent needs of the motion pictures industry prompted, however, the silencing of the check-pawl ultra-speed mechanism which was extensively used in slow-motion cinematography.

Improvements brought about in this movement, consisted mainly in the substitution of formica for steel gears, in the setting of the film tension at from 1½ to 2 ounces, and in the elimination of four out of six driving fingers eliminating the noise formerly produced by the pawls clearing the film perforations as they passed back for a new hold on the film.

Figure 4 shows at "A" the film gate open, and at "B" the

closed mechanism with cap removed, disclosing the formica gear and the anti-reverse locking spring.

Through these alterations it has been possible for the Engineers of the Bell & Howell Company, to contribute to the advance of sound and talking pictures by evolving a camera suitable for work on the sound stage and which has proven, through actual demonstrations conducted in the course of production, that it can be safely set and

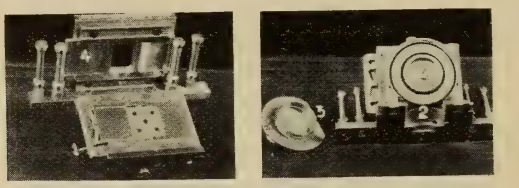

SILENCED CHECK PAWL SUPER-SPEED MECHANISM
1 FILM FEEDING FINGER
2 FORMICA GEAR
3 ANTI-REVERSE LOCKING SPRING
4 RELIEVED APERTURE PLATE

FIGURE 4. Silenced B. & H. check pawl super speed intermittent mechanism.

operated, without the protection of a booth, as close as from eight to ten feet from the microphone without any of its noises registering and being detrimental to the recording of sound and voice.

Part Two: A New Silent High-Speed Intermittent Mechanism

The intermittent mechanism of a motion pictures camera is, so to speak, the heart of the whole instrument, since upon it depends the precise registering of the rapidly succeeding photographic records.

The intermittance of movement has from the very beginning of motion pictures, put to task the inventive genius of motion pictures engineers, in order to solve the problems involved in the designing of a mechanism which would, while working at a speed of 16 pictures per second, perform a cycle of four main and distinct movements.

I: The engaging of the film-feeding fingers into the film perforation.

II: A downward movement of the fingers to bring an unexposed portion of the film in the proper position in front of the camera aperture.

III: A backward movement to withdraw the fingers from the film perforations.

IV: An upward movement of the fingers to bring them in position to reengage into the film perforation and repeat the cycle.

During this cycle of movements, the shutter of the camera was to make one complete revolution.

The mechanical problems inherent to this rather complex cycle of movements had been happily solved with a reasonable disregard of the noises resulting from the functioning of its parts, all attention being paid to the accuracy of registration and the elimination of any possibility of damaging the surface or the perforations of the film.

In due course of time, intermittent movements were developed, which permitted a considerable increase in the photographing speed, that is to say, in a considerable increase of the number of frames which could be exposed each second.

A paper introducing such a mechanism capable of performing as high as 200 cycles per second was presented to this Society at the Spring Convention of 1923.

Again, the noises inherent to this mechanism, were to some extent, disregarded.

The advent of sound Motion pictures demanded a mechanism capable of noiselessly completing at least 24 cycles per second and also capable of withstanding a much more strenuous usage than the movements in existance, due to the fact that the average length of scenes taken for sound purposes is at least four to six times greater than the average length of scenes photographed for the silent drama.

At the same time that the feverish demand for camera equipment suitable for sound work brought about the silencing of existing mechanisms, the camera engineers did not consider this adaptation as quite sufficient for the needs of the new industry and the designing of a new mechanism was deemed highly desirable.

The main prerequisites of such mechanism are the absence of noise and the ability of performing at a minimum speed of 24 pictures per second (90 feet per minute) while conserving intact the

indispensible attributes of perfect registration, forward and backward movement and an as complete as possible elimination of friction upon the surfaces of the film, in order to avoid the evils of scratches and abrasions.

The mechanism being described in this paper is the latest contribution of the Bell & Howell Company to the Motion Pictures Industry.

In order to simplify its description, we shall consider one after another its principal parts, namely:

The Film Channel
The Film-feeding fingers
The Registration fingers

and conclude with a brief description of features of general interest, such as the lubricating system and the general assembly of the mechanism.

THE FILM CHANNEL: The film channel can be divided into three main sections, an upper and lower curved sections each having a radius of 1¼ inch and a central plane section.

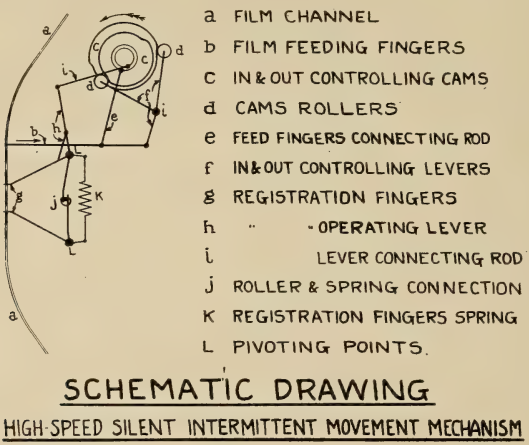

a FILM CHANNEL
b FILM FEEDING FINGERS
C IN & OUT CONTROLLING CAMS
d CAMS ROLLERS
e FEED FINGERS CONNECTING ROD
f IN & OUT CONTROLLING LEVERS
g REGISTRATION FINGERS
h " - OPERATING LEVER
i LEVER CONNECTING ROD
j ROLLER & SPRING CONNECTION
K REGISTRATION FINGERS SPRING
L PIVOTING POINTS.
SCHEMATIC DRAWING
HIGH-SPEED SILENT INTERMITTENT MOVEMENT MECHANISM

FIGURE 5. Schematic drawing of the new B. & H. high speed speed intermittent movement mechanism.

Figure 5 shows a schematic drawing of the mechanism plainly illustrating the above mentioned essentials, Film channel, Film-feeding fingers and registration fingers.

The film-feeding fingers operate in the upper curved section,

while the plane section comprises the camera aperture and the location of the registration fingers.

The central plane section of the film channel has been kept within the shortest possible length in order to insure perfect flatness of the film surface at the time of exposure.

The longitudinal curves impressed upon the film by the curved sections of the channel, in conjunction with the transverse guide and tension plates, prevent any possibility of the film sagging or curling even under very severe temperature conditions. The film is thus kept under control throughout its path in the channel and the presentation of a perfectly flat film surface at the focal plane of the photographic lens is thus assured.

The film channel consists of two members. The film is inserted in the space thus provided for and which is so designed as to provide a frictionless surface passage of the film through it.

A light spring pressure of the aperture plate against the body of the movement prevents possible injury to the film or to the mechanism, should the film be threaded improperly.

The aperture plate, is provided with a lock and the film cannot be introduced into the channel if the lock is not in its engaged position. This arrangement eliminates all possibilities of neglecting to lock the aperture when the mechanism is replaced in the camera after having been withdrawn from it for the purpose of cleaning even if this operation is performed under the greatest possible pressure of urgency.

A very light tension at one side of the film keeps it registered sidewise against a solid rail.

Figure 6 shows the arrangement of such tension which is exerted only on the portions of the film which assume the curved shape of the film channel.

The point on the floating tension plate at which the pressure is applied was determined by careful calculation, and is so located as to assure an equally distributed pressure along the entire side tension-producing surfaces.

THE FILM-FEEDING FINGERS: The function of the film-feeding fingers, is to engage in the perforations, carry the film downward or upward, according if it is desired to record the motion of the subject normally or reversed, to withdraw from the perforations and resume its original position as at the beginning of the stroke.

The ideal IN and OUT movement of the film-feeding fingers would be the one in which the motion occurs at a time when there is no contact between the fingers and the faces of the perforations since the inevitable wear which occurs at the end of the fingers, is caused by the rubbing of the surfaces which contact with the faces of the perforation.

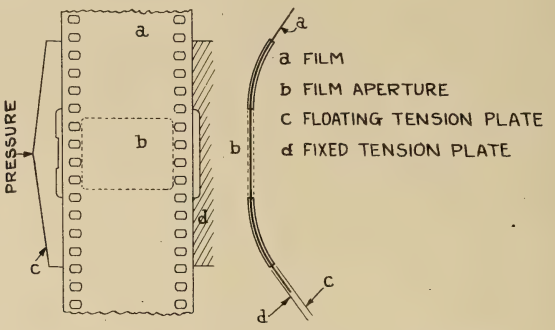


FIGURE 6. Film tension in the new B. & H. high speed intermittent movement mechanism.

In the new mechanism here presented, the entire feed forward movement of the fingers has been held to only .012″ and only 1/6 of this total displacement, or .002″, is the extremely short motion which takes place from the time at which the fingers begin to engage in the perforations, until the entire IN movement is completed.

The ideal movement, is the one in which the total shutter covering time and the film advancing time are equal with the acceleration produced by a constant force.

In Figure 7 curve "A" represents the acceleration due to a constant force, that is to say, GRAVITY. Curve "B" is plotted from the downward movement of the film.

It will be noticed that during a complete from top to bottom stroke, the acceleration and deceleration of the feeding fingers lie very close to the ideal. The variation is very slightly greater in the deceleration.

It is because the ideal acceleration condition is so closely met that the time necessary for the IN and OUT movement of the feeding fingers has been reduced to the smallest extent.

The amount of noise produced in intermittent movements by the rapping of the film-feeding fingers against a stationary film, is determined by the amount of "play" between finger and perforation.

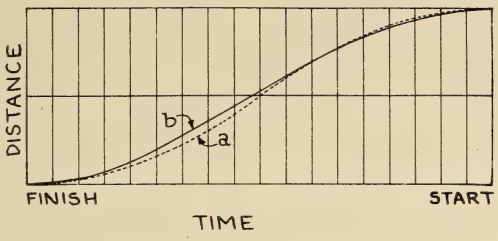


FIGURE 7. Comparative curves of the acceleration by a constant force with the acceleration obtained through the movement.

In the movement here presented, the film-feeding fingers are .008″ narrower than the film perforation, which condition limits the overthrow to .004″, that is to say, the film-feeding fingers move along a path only .004″ long before touching the faces of the perforation.

The extent of displacement is so small that the downward movement of the fingers is extremely slow at this moment, so that they may practically be considered as stationary at the instant in which they actually come into contact with the film perforation.

To insure a still greater resistance to wear, the ends of the film-feeding fingers are chromium plated.

In Figure 8 are shown five schematic drawings of the mechanism, at five different phases of movement.

It is well to remark that the schematic condition of the drawings does not permit illustrating the extremely small overthrow previously referred to.

In position 1, the film-feeding fingers are withdrawn from the perforations and the registration fingers are holding the film stationary by spring pressure. [Note: Experiments are being conducted to eliminate the use of springs].

In position 2, the film-feeding fingers are shown during their upward motion. The film is still held in position by the registration

fingers and remains so while the shutter (not shown in the drawing) is functioning in the exposure condition.

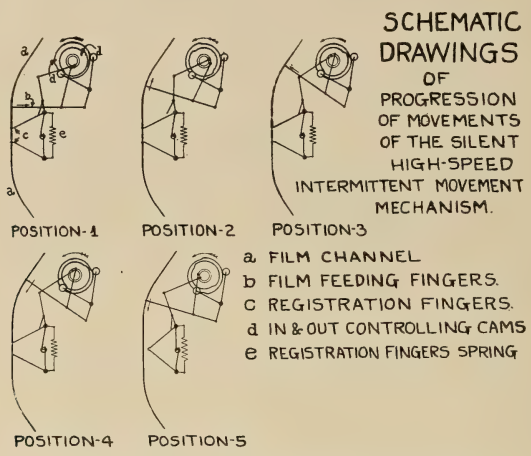


FIGURE 8. Schematic drawings illustrating different phases of the cycle of movements performed by the new B. & H. high speed intermittent movement mechanism.

In position 3, the film-feeding fingers have reached the end of their upward stroke and are advancing into the perforations. The registration fingers are still engaged.

In position 4, the film-feeding fingers have moved forward slightly and the registration fingers are withdrawing. This phase of the movement is difficult to illustrate in proper proportions since it involves the simultaneous motion of feeding and registration fingers which covers distances but a few thousandths of an inch long.

In position 8, the film-feeding fingers are carrying the film downward and the registration fingers are in their retracted position.

The *IN* and *OUT* movement of the fingers is accomplished by means of two adjoining cams which are integral parts of the crank shaft. These cams provide positive forward and backward movement to the fingers and eliminate the use of springs.

No damage can possibly result from undue friction or strain upon the film perforations.

The motion producing surface of each cam subtends an angle of 12° which is but 1/30 of its periphery. There is no load upon the inactive parts of the cams.

The cam's rollers are freely fitted in their sockets, they creep around very slowly while in contact with the active zone of the cam and each point of their surface incurs an equal amount of wear. They can easily be removed and replaced in their sockets without the use of tools, should the inevitable wear produce any loose motion.

The lubrication of the cams and rollers is assured by oil saturated felts which are in constant contact with the periphery of the cams.

The exposure condition is met by this new mechanism as in the usual 170° shutter cameras.

THE REGISTRATION FINGERS: In order to insure the perfect registration of each photographic image on the film and to insure that there will be no motion in the film during the time of exposure, two pairs of registration fingers have been provided in this mechanism.

These fingers engage the perforations at the end of the film-feeding stroke, become stationary when fully engaged and remain so until the beginning of the following stroke.

The manner in which these fingers size the film, is entirely new.

At the moment at which they have fully completed their forward movement, they become wedged against the faces of the film perforations by spring pressure. The film itself serves as a stop for the fingers, and the spring pressure locks both fingers and film, assuring absolute rigidity and perfect registration.

The registration fingers are also chromium plated in order to insure their longest possible life.

PIVOTS AND BEARINGS: There are only three points in the mechanism where bearings are used.

The pivot bearings are adjustable and very generously calculated so that the perfect functioning of the movement is assured throughout its life.

LUBRICATION: The cams and rollers are lubricated as previously explained by felt wicks and the same system is used for the constant lubrication of the other rapidly moving surfaces. Oil holes are provided for the proper lubrication of the other parts of the mechanism.

GENERALITIES: The movement proper is built around a single piece of hardened steel.

All holes which are to receive pivots and bearings are bored after hardening, with tolerances of .0001".

The movement is entirely enclosed in an aluminum cap which serves the threefold purpose of rendering the mechanism light-proof, of preventing the spattering of the lubricating material within the camera and on the film when the movement is working at full speed, and as a protection against dirt from outside sources.

Provisions have been made for the mounting of a total reflection prism in the aluminum cap of the mechanism, so that a direct focusing magnifying optical system can be mounted on the camera.

The installation of this new mechanism in the Bell & Howell camera is extremely simple, and requires, as the old movement, only to be slipped in the proper position and fastened there by two clamps.

No alterations of the camera are necessary except for the main cam, in which a worm has to be mounted to drive the mechanism itself and for a hole to be bored in the inner frame of the camera in order to provide space for a gear which is driven by the worm.

The whole mechanism which, as it has been seen, is built upon very simple lines, is remarkably small in size and presents at the same time all the necessary requisites of remarkable sturdiness and endurance.

An extremely careful adjustment of all its part insures a most perfect functioning as well as a total absence of the noises which are so detrimental to the making of sound and talking pictures.

DISCUSSION

DR. GAGE: How fast can this camera operate?

MR. DUBRAY: I cannot give an exact answer as to speed. The movement is, at this time, still undergoing endurance tests, but I may venture that to all probabilities, it will be capable of a speed of eight to ten times the normal of sixteen pictures per second. That is, it will be capable of a speed of approximately from 128 to 200 pictures per second.

MR. RICHARDSON: I should like to ask whether the film is pulled around the curve under tension.

MR. DUBRAY: The film has a free running without pressure ten-

sion. As shown in figure 6, the side tension is applied on both curved sections of the channel.

The side pressure of the floating rail is uniformly distributed along the entire curved sections of the film channel.

MR. RICHARDSON: I should suppose that there would be a tendency to scratch the film by reason of dust particles in the air.

MR. DUBRAY: The danger of scratches is so minimized in this movement that it can be considered as eliminated.

The absence of pressure against the face of the film, the hardness and polish of the steel plates, and the fact that the movement is enclosed in an air tight casing, which prevents dirt penetrating into it, reduce the danger of scratches to a very minimum.

The resistance of the side tension against the feed fingers causes the film to run against the aperture plate.

Normal care in keeping the movement clean, which is made very easy through the facility with which the aperture plate can be removed, further insures the minimizing of the "scratch evil."

MR. ROSS: Does the position of the belt tightener require more power being used?

MR. DUBRAY: I cannot answer this question with engineering accuracy, but I am sure that if any more power is needed, this is negligible, especially if compared with the power necessary to take up a 1000′ roll of film.

The power of the synchronized driving motors in general use is amply sufficient to take care of that.

A PRINTER FOR SIMULTANEOUS PRINTING OF SOUND AND PICTURE NEGATIVES

Oscar DePue*

THE printing of sound pictures on a rapid basis is, of course, only possible by a continuous machine, and the possibility of a rapid continuous machine being used has been greatly enhanced by having a suitable automatic light control. This, we believe, is the advantage of the machine we are trying to develop over a slower method of manual control or a limited automatic control. The fact that both sound tract and picture printing light should be controlled by automatic means gives our very large capacity, automatic control a chance to demonstrate its worth in the art.

Moving a negative past a narrow aperture was the very first means employed by the writer in printing positives as early as 1897, when a 60 mm. film was used. To compensate for the shrinkage and the holding of these two films in contact, two sprockets were employed, geared together, the negative sprocket being a trifle smaller to allow for the difference in shrinkage. The control of the lighting, however, at that time was unheard of so far as the automatic means was concerned. The method used was to move the light backwards and forwards to correspond with the different densities which, of course, limited the speed of printing. The automatic change by resistance, which we are now employing, has stood the test for over ten years in our work, as applied to a continuous movement past a narrow aperture. In fact, the combination is a good one, as the continuous movement and the comparatively gradual change of illumination from weak to strong, or reverse, spreads the change of light over a sufficient distance on the print to give the effect of a fade-in or fade-out, as it were, and no rapid or abrupt change takes place in one or more frames of the print.

One of the important features of a printer of this kind, we have found, is that the printing should actually take place just as near as possible to the point on the sprocket wheel where the film is striped from the teeth. We have also found that the size of the sprocket wheel is very, very important. We worked at first on the

* DePue and Vance, Chicago, Ill.

theory that a sprocket wheel should be made to fit or accommodate any negative, old or new, but found that, so far as the sprocket holes were concerned in fitting the teeth, it was more or less a snare and a delusion; for while making the wheels small enough to accommodate twelve or more teeth engaging at one time, it brought on troubles when employing a new or unshrunken film, as it then allowed movement to take place, not only at the very point of printing contact with the negative, but allowed the film to have a movement throughout its entire contact with the sprocket teeth. But by making the sprocket wheel larger in diameter and by making the teeth less thick at the base, there was very little, if any, movement taking place at the actual point of printing. This, then, is the theory on which we proceeded to construct a sprocket wheel which would accommodate not only a new film but one somewhat shrunken, as well.

Now, we have found that a speed of eighty or eighty-five feet per minute has been a very practical one for printing continuously by means of our automatic light resistance control. Eighty-five feet per minute is a speed not too great for the light change, over a wide range of variations, to take place without a disagreeable effect on the eye, and so far as we have been able to determine, the quality of the picture was not changed when printing at this speed, or a very much slower one. Sufficient light to bring up a picture in a certain time for developing is necessary in either case, and running slower and getting very much less light to make up for the difference appears to be unnecessary. Therefore, a high speed is very much to the advantage of the laboratory.

There has been considerable discussion and writing regarding the back lash or movement of the sound printing sprocket wheel past the very narrow opening necessary. Of course, it is a well known fact that when employing the alternating current for the light source as well as for the motor drive of a continuous printer, where the aperture is sufficiently narrow, there will be traveling lines or varying exposures on the film, brought about by the light filaments fluctuating in synchronous movement with the motor; but it is also well known that where the aperture is of a certain width, this defect is eliminated, and we have found that an opening of one-fourth of an inch in width is allowable in using the alternating current on the light as well as on the motor. We have built

this printer on the theory, however, that most laboratories are equipped with the direct current for their light sources, and therefore, have divided the machine into two parts so that the printing lamps can be used on the direct current; this is to allow the sound tract opening to be closed down to any width desired. Our tests show that we can employ the same lamp for the sound tract as in printing the picture, and therefore, can keep the construction of our automatic light change uniform for all printers for which they have so far been used. They take 100 watt lamps for continuous printing, and 250 watt lamps for step optical printing.

In making tests on the sound tract opening, we have not yet discovered any defect in printing at this rate of speed and with an opening of three-eighths of an inch. In fact, we think that with the direct current, and that size opening with a sufficiently strong illumination such as a 100 watt lamp, it is perfectly practical when driven by the means we have employed in that connection; that is, a worm drive of 16 2/3 to 1 and coupled directly to the motor by a universal joint. This means gives the driving sprocket wheel a very uniform and continuous speed of 103.6 revolutions per minute. Our drive for the picture negative is transmitted from this sound tract sprocket shaft directly to the sprocket wheel of the picture aperture. Any slight variation in the movement, if it should occur, would not be serious in this way of driving, while the reverse method might have more or less serious defects on the sound tract printing.

It has seemed advisable to build a machine which would handle a thousand foot reel of film with one automatic light set-up and as a continuous unbroken print for developing machines. Therefore, this machine running eighty feet per minute will print a one thousand foot reel in just twelve and one-half minutes, if running continuously. That is at the rate of forty-eight hundred feet per hour, if negatives of that length could be handled without a stop. By allowing for four thread-ups and rewinding of the negative (of course, the rewinding of the positive for printing is eliminated and that time is saved), it is safe to say that three thousand feet or possibly three thousand five hundred feet, with a more skilled operator, is to be expected from this speed of printing.

Up to this point I have not dwelt on the fact that this printer has been developed to print from two negatives, the sound tract negative being handled as a separate negative which, of course, will

allow the printing to be completed in one operation through the machine. We are also of the opinion that where the picture and the sound tract both appear on a single negative this machine will still be able to handle the print in one operation, by merely allowing a sufficient loop between the picture aperture and the sound aperture, which should place the sound print at its proper distance from the picture print on the finished positive. There may be one technical difficulty in this operation and that will be the handling of the light control for the sound tract. Of course, there will be a notch for each picture change, and this notch will have to be accounted for on the automatic light control of the sound tract. This may be accomplished by merely allowing the light change to take place on the same light, whatever that may be set up for, and varied at the points where variation is necessary, or it may be that notches on the opposite side of the film can be employed for this second light control so that there will be no connection between these two light changes, excepting that each negative will have its own notchings for this purpose. Avoiding the necessity of rewinding the positive print and the time saved in the second threading operation should add considerably to the volume of film which can be printed in a day's time.

There is one other point which we have tried to cover in the construction of this machine and that is, at the point of contact, at the aperture, we have recessed the pressure plate a very few thousandths of an inch and blackened that surface so that there will be no back lighting from a reflecting surface thru the positive film. The fact that all cameras have a blackened backing for exposure to light is so well known that it has seemed strange to us that this fact has not been taken advantage of in printing, but it is a well known fact that, up to the present time, all continuous printers have been made with a highly polished steel pressure plate which, of course, reflects a certain amount of light, which in turn, softens down the finished print; and this effect is probably what has caused many critics to favor a step printer, which of course, has no reflecting surface, and as a result, the finished product appears to be snappier and of better quality. We think, however, that a direct comparison of prints made on our machine and a step printer will reveal the fact that this darkened surface adds greatly to the snappiness and quality of the finished product. We have employed this same device for the sound

tract also, which should give a snappier print at that point as well as the picture image.

It is needless to say that we have had very little experience in the technique of sound printing, not being in the producing and processing of sound pictures, and it is needless to say that we have had very little assistance up to the present time, in so far as knowing what to give the trade is concerned. The writer visited several laboratories last fall but was unable to see a single printer arranged for sound printing or to gain any information as to how it was done or what was wanted. In fact, in the only instance where a machine was even visible, it was immediately covered before the writer got within fifty feet of the apparatus. Therefore, we have had to work along on the information which we have gathered from time to time, especially from articles contributed to the Society of Motion Picture Engineers Conventions and the various camera publications and our own knowledge in general as to how a printer should be constructed for doing ordinary printing. The sound part we have had to take more or less on chance. Possibly, no one was more surprised than ourselves when our very first sound picture began to talk to us, and as it seemed to have a fairly clear voice and the quality of the picture was not unpleasing, we have ventured to present this machine and this article to this learned body of men with apologies and the hope that you have not been bored by this lengthy paper.

I shall be glad to undertake to answer as best I can the questions which may arise in your minds regarding this machine.

DISCUSSION

MR. CRABTREE: For what negative shrinkage is the printer sprocket designed? Also, if you run a piece of positive film over the film sprocket without a negative, is the density obtained uniform or is there non-uniformity due to the fact that you don't have a mechanical filter between the driving mechanism and the sound sprocket?

MR. DEPUE: It drives directly from the sound sprocket. There is a worm driven sprocket here, and the gear is not necessary; it goes straight on to the sprocket, so that this wheel (indicating) gets the least possible motion, and from there we drive this mechanism. We don't have any gears or belts.

MR. CRABTREE: Have you made a test to determine the uniformity of the motion of the sprocket?

Mr. DePue: We made a test although we had only two little negatives but when we projected this in the theatre, relying on our own ears and the manager's and employee's, it seemed to be as good and better than some. The shrinkage in the film has been experimented on considerably, and I can draw a little description of what we have found on the sprocket wheel and size of the teeth in continuous printing. We will illustrate this (drawing) as the size of the sprocket wheel, which is 12 frames, and this small size sprocket warps the film more closely together than on the larger size. The film appears to be in perfect contact without the aid of air, which I know you are anxious to get away from; it takes another motor and compressor and all that sort of thing. This represents a sprocket wheel (drawing) and this the tooth. The average film should be printed at the point where it leaves the tooth, engaging in ten or twelve teeth. Here is the tooth engaged in the film. By making the sprocket wheel a certain size it should be large rather than small. If you make a wheel small enough for shrunken film there is trouble with the unshrunken film. That makes a movement in the film, which may happen at the printing point, and you have lack of contact. This tooth should be very thin—not wide enough to fill the whole sprocket hole—so that there is some space on either side of the sprocket tooth (indicating) on the negative (here) and when it reaches this point it should be free, so that the actual engaging of the film will be on the first tooth. With a wheel of the right size and the tooth small enough, it engages only right here (indicating printing slot). We found one of the greatest secrets in printing is the teeth on this wheel, and the teeth should be backed off, so that when they enter the sprocket hole the edge does not touch the edge of the perforation at all.

Mr. Crabtree: You didn't exactly answer my question. For what shrinkage of the negative is your sprocket designed? When printing over a sprocket with the positive film uppermost and the illumination coming through the sprocket as in the Bell & Howell continuous printer, in order that there shall be no slippage of the films their angular velocity must be constant though the linear velocity of the positive is greater than that of the negative depending on the diameter of the sprocket. The Bell & Howell printer sprocket is so designed that for a negative film shrinkage of 0.3 per cent there is little or no slippage when printing onto fresh positive film stock.

MR. DEPUE: I can't tell you on technical terms what the shrinkage is, but the film five or six years old is all right and so is new film. The title is the try-square of the whole business. If you can print a title, you can print the picture. We know how to make the size right to fit the different films. The size of the tooth has more to do with this than you may think.

MR. E. RICHARDSON: It seems to me that Mr. Crabtree's question answers itself. The film has contact only on one side and considerable latitude on all others, so that no film would shrink enough to make a difference.

MR. DEPUE: You can enter the film wherever you want.

MR. RICKER: You are overlooking the fact that that is cumulative.

MR. DEPUE: We do not engage a sufficient number of teeth in the perforations to make it cumulative.

MR. RICKER: Well, of course, the next tooth will pick it up.

MR. E. RICHARDSON: Why do you use those teeth then?

MR. TAYLOR: It seems to me that Mr. Crabtree's question is not appreciated. The positive, being new, is longer than the negative, so that there will be a radius of the drum when both roll, one not slipping on the other. What is the radius of the drum? Is it more or less what Bell & Howell use?

MR. DEPUE: Ours is a 12 frame sprocket and the Bell & Howell 16, which determines the whole thing.

DR. E. COOK: What was the subject matter of the films you used?

MR. DEPUE: A travel film made six or seven years ago and the film made a few days ago.

DR. E. COOK: Do you notice any effect of variation in speed if you print a constant frequency film? I believe this is what the General Electric Company calls "wow-wows" in speaking of the sound track.

MR. DEPUE: We printed with DC on sound and AC on picture.

DR. E. COOK: I mean constant frequency on the film.

MR. DEPUE: We have had little chance to experiment with these things which are familiar to you but which we don't know about.

MR. TAYLOR: I am going to try again to make this point clear. Mr. Cook wants to know whether it was made on pictures or music

and if so on a frequency. It is easier to check on a constant note. Speech causes fluctuation in tone and in complicated music with many instruments it is not so evident, but a single sustained note is the best way to tell whether the tone is uniform. Do you use an AC lamp for printing?

MR. DEPUE: You can use AC on aperture opening five-sixteenths to three-eighths inch on picture aperture only.

MR. TAYLOR: How about sound?

MR. DEPUE: We have not tried the experiment (laughter). One was music and the other speech. It seemed to sound all right.

TYPICAL SOUND STUDIO RECORDING INSTALLATIONS

H. C. Humphrey*

IN THIS age of diversification it is to be expected that different individuals and different groups will have different ideas regarding the methods which should be followed to produce the results they have in mind. This condition exists to an unusual degree in the motion picture industry, and it may, therefore, be presumptuous on my part to attempt a description of a typical sound studio recording installation. I shall, however, attempt to place before you not only some typical studio layouts but to bring also to your attention a few of the factors which have influenced the design of these layouts.

In selecting and estimating the space required for sound recording studios, consideration must be given the following:

1. Number, size and arrangement of:
   - (a) Sound stages
   - (b) Monitor rooms
   - (c) Recording Buildings
   - (d) Cutting and review rooms

2. Location of studios and monitor rooms with respect to sources of outside noises and probability of these outside noises getting into the sound stages or monitor rooms.

3. Possibility of sounds being transmitted from one studio or monitor room to another.

4. Facilities for power, ventilation, and refrigeration.

Consideration of these factors establishes whether or not an existing stage can be used for taking sound pictures and the modifications necessary to make it suitable for sound work.

The number of sound stages depends, of course, on the requirements of the producer. Figure 1 shows a typical four stage layout. Stages thus located with respect to each other can be operated absolutely independently and without fear of sound from one stage getting into the other.

Figure 2. shows a particularly compact four stage unit but one which is potentially subject to likelihood of crosstalk from the following causes:

* Electrical Research Products, Inc., New York, N. Y.

(a) Transmission of sound from one studio or monitor room to another because of common walls, roof, or floors.

(b) Noise entering ventilating and heating ducts and being conducted from one monitor room or stage to another.

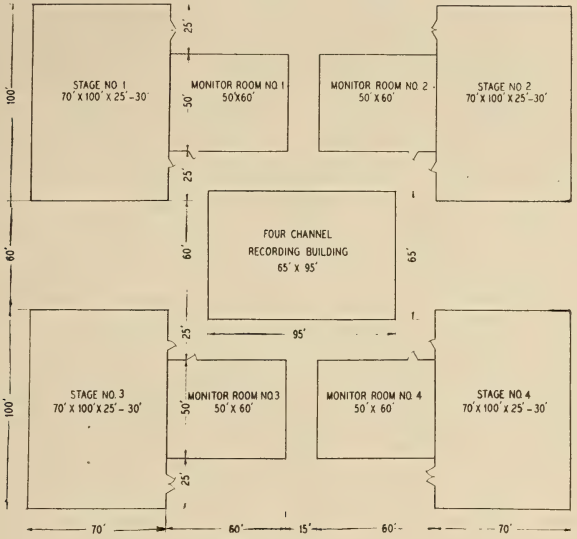


FIGURE 1.
Typical Four Sound Stage Layout

(c) Pipes or electrical conduit passing through more than one room or stage, if hit sharply, will conduct this noise to the other rooms or stages.

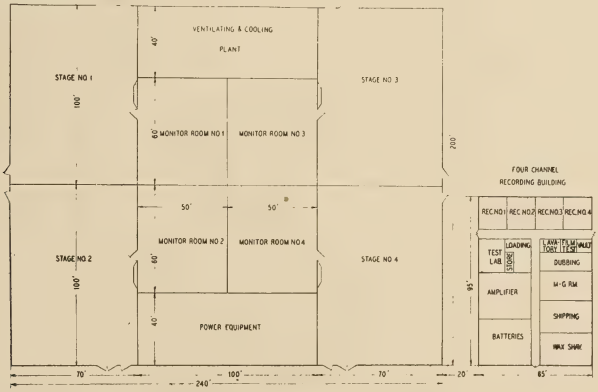


FIGURE 2.
Typical Four Sound Stage Layout

An advantage of the layout shown in Figure 2 is that the stages may be designed with hinged sound proof doors between any two stages and when particularly long camera shots are required, by opening these doors the two stages can be made into one large stage.

The size of stages is largely a matter of choice with the producers. The 100×70 size seems to be popular. The height of sound stages depends upon their width and length.

It is essential when making a recording to be able to predetermine, so far as is practicable, how that particular recording will sound when reproduced in a theater. In other words, we desire to see the action on the set and to hear the corresponding sound as it would sound coming from the loud speakers behind the screen in a theatre. For this purpose a monitor room is provided. This monitor room is so located with respect to the stage which it serves, that through the use of a "mixer balcony," consisting of a glass bay-window, and elevated platform, the mixer operator is afforded as complete a view of the stage as is practicable. Also, in this monitor room is a loud speaker connected to the recording apparatus.

There should be as many monitor rooms as there are recording channels operating simultaneously. Usually this means one monitor room for each stage although as will be shown later, one monitor room may be arranged to efficiently handle two stages.

The size of monitor rooms is compromise. All theatres are not alike, some are small, some large, some have heavy carpets and draperies and plush seats, while others have more or less hard surfaced walls and perhaps wooden seats. In other words, the acoustics of theatres vary widely. Experience has indicated that a room 50′×60′×30′ properly treated acoustically gives a fairly satisfactory approximation of average theatre acoustics. Recordings which sound well in such a monitor room are well adapted for reproduction in theatres.

It is quite likely that as the art advances, ways other than through the use of a large monitor room may be found to approximate theatre acoustics. It is also possible that monitor rooms may be entirely done away with, and instead a head-phone network used, having the frequency characteristics of the theatre horns, and the acoustical characteristics of an average theatre. No matter how the effect be obtained, the importance of recording studios

taking into account the acoustics of theatres when making voice balances cannot be too strongly emphasized.

Technical equipment such as motor generators, storage batteries, amplifiers and recording machines, have no place on stages already over-crowded with sets, carpenters, electricians, lights, artists, extras, directors and what-not. Moreover centralizing the major part of such apparatus in a single "Recording Building" serving several stages, facilitates technical administration and maintenance and provides maximum flexibility and interchangeability.

A typical Recording Building serving four stages is shown in Fig. 3. Two to eight stages can be economically handled through

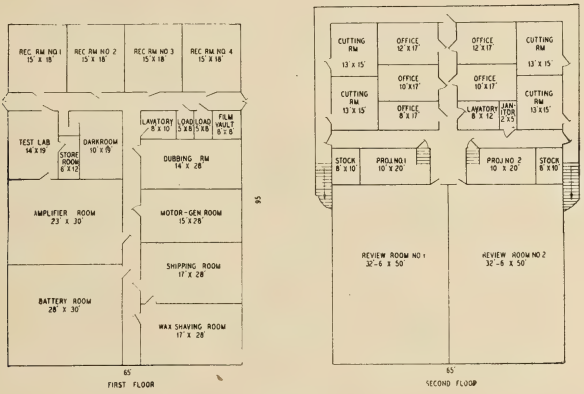


FIGURE 3.
Typical Four Channel Recording Building

one recording building or center. Beyond that, it is desirable to duplicate with as many more recording buildings as may be required, at strategic locations. In some instances it is desirable to make the Recording Building two stories high and to use the second floor for sound picture review rooms and for sound cutting rooms. The cutting rooms present no new problems. The review rooms should be as large as possible in order that the reviewer may get the effects obtained in a theatre.

In laying out the Recording Building, the prime consideration has been to keep the shortest possible leads between batteries and amplifiers and between generators and batteries. In the amplifiers themselves every precaution has been taken to guard against undesired voltages being introduced into the input circuits. The vacuum

tubes in the initial stages of amplification have been protected against mechanical vibration or possible vibration of the tube elements, due to sound waves impinging on the glass bulb. Fortunately, telephone engineers had already encountered these very problems and so the benefit of their experience was immediately available in the design of the recording amplifiers.

The amplifier circuit layout is so arranged that no adjustment of the amplifiers is necessary while in operation; gain control being done entirely on the monitor platform in the monitor room and except for occasional observations of filament and "B" battery

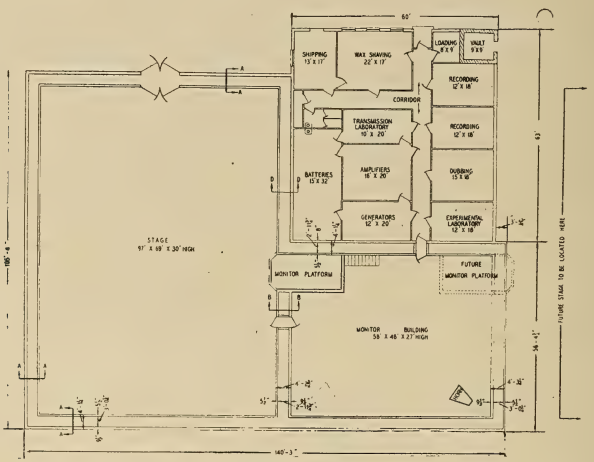


FIGURE 4.

current, the amplifiers require no attention. This permits a minimum of personnel in the amplifier room and tends to eliminate the hazard of amplifier tube elements being set into vibration due to either movement or conversation of personnel in the amplifier room. Fig. 7 shows the amplifying equipment for a single channel. For each additional channel this equipment is duplicated.

Upon installation, further precautions are taken by using twisted shielded pairs of wires for speech circuit interconnections, and by mounting the main amplifier base on a special concrete foundation as shown in Fig. 6. As an extra factor of safety against "acoustic pickup" or "feed back," the producers are cautioned not to use a loud speaker in the amplifier room unless for testing purposes.

I shall not attempt to describe in detail each of the typical

layouts shown. This paper will be limited to the description of one of the smaller type installations which has made some of the best sound recordings, with equipment exactly as originally installed.

In this particular instance specific and somewhat limited space was available in which the producer desired to provide for two sound stages ultimately, although initially contemplating the erection of but one stage. The initial requirements did not provide for any Cutting or Review Rooms as the intent was to locate these elsewhere. At the time, it was felt that possibly one Monitor Room

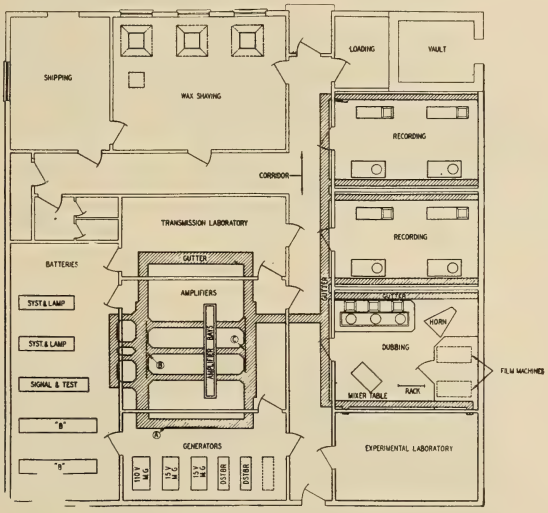


FIGURE 5.
Recording Building and Equipment Layout
A. Distributor and Motor Control Switchboard
B. Battery Switchboard
C. Main Frame

could be made to efficiently and adequately serve two sound stages. These stipulations resulted in the layout shown in Fig. 4.

Before the construction for the first stage was completed, the producer realizing that a single channel would probably be inadequate for his requirements decided to immediately go ahead with the construction of the second stage, and at the same time to provide this second stage with its own Monitor Room. It was also decided at this time that provision should be made for Cutting and Review Rooms to serve both channels. These additional requirements were met by duplicating the layout shown in Fig. 4. Since

the original Recording Building was designed with facilities for two complete recording channels, this allowed us to utilize the second recording building for Cutting and Review Rooms.

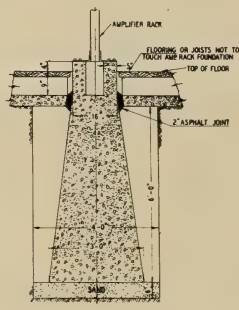


FIGURE 6.
Cross-section of Amplifier Rack Foundation

Fig. 5 shows in detail the layout of the original Recording Building. Since the ultimate plan was for stages on both sides of the recording building and since the monitor building was at one end, there was left only one side of the recording building opening

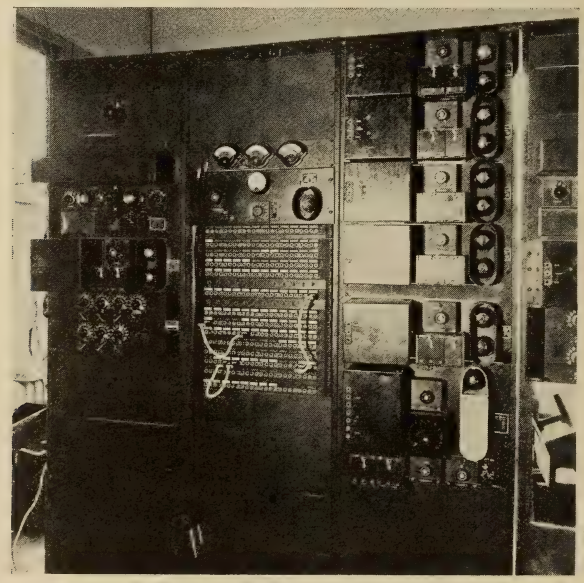


FIGURE 7.

to the street. Naturally, the shipping room was placed at that end, together with the wax shaving room, immediately adjacent, so that the handling and shaving of waxes may be carried on without interfering with the other operations in the recording building. The

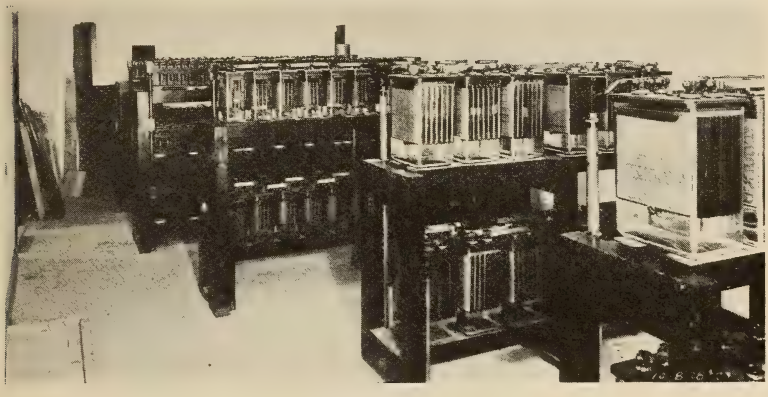


FIGURE 8.

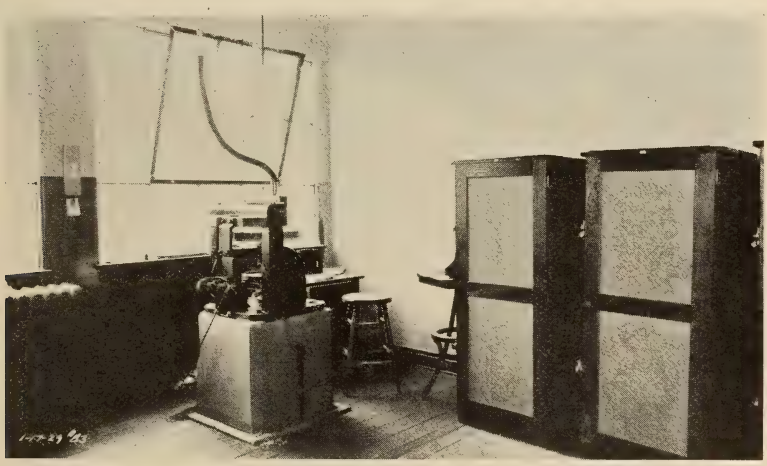


FIGURE 9.

film vault had to be on the outside of the building, and the only place left for it was the location shown.

Fig. 9 shows a view in the Wax Shaving Room. In this room are located the machines for re-surfacing used waxes and for putting

on the mirror-like finished top surface considered so necessary by wax recording men. These machines are fairly massive and rigid in order to insure against vibration or chattering of the shaving knives or feed mechanism. The machines are mounted on individual concrete foundations which are isolated from the recording building floor as shown in Fig. 10.

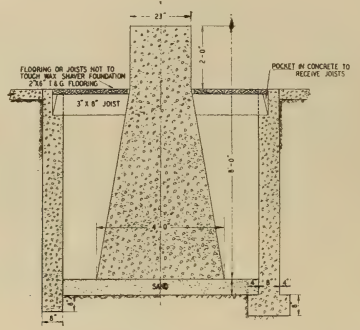

FLOORING OR JOISTS NOT TO TOUCH WAX SHAVER FOUNDATION
2"x6" T & G FLOORING
3" x 8" JOIST
POCKET IN CONCRETE TO RECEIVE JOISTS
SAND

FIGURE 10.
Cross-section of Wax Shaving Machine Foundation

Next, the two recording rooms were considered with the principal thought in mind of having them as close to the sources of film and wax supply as possible. Hence their present location. Because of the space limitations imposed it was necessary to re-

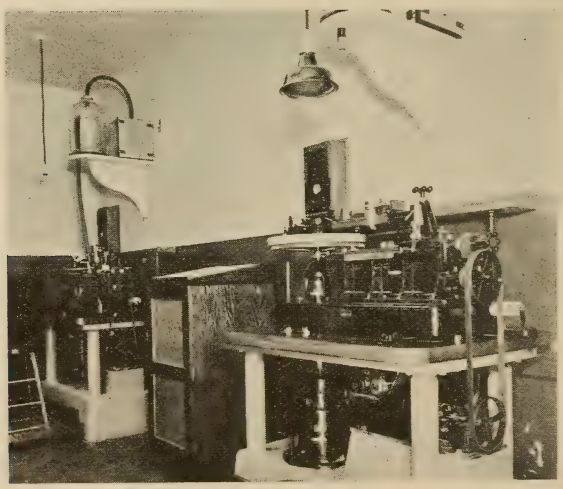


FIGURE 11.

strict the size of these rooms to 12′×18′. Normally it is desirable to provide a standard sized recording room, which is 15′×18′. Fig. 11 shows the arrangement and method of mounting the disc recording machines. A layer of cork is placed between the concrete base and the floor which helps to prevent building vibrations being transmitted to the recording machines.

It will be observed that there are no windows in the recording rooms or in any of the other rooms except the shipping and wax

FIGURE 12.

shaving rooms. This was necessary on account of the proposed future stage. Instead of windows, skylights were specified.

A view of the dubbing room is shown in Fig. 12. Had the space been available it would have been slightly more preferable to have had this room nearer the source of wax and film supply.

Two complete sets of storage batteries are provided, and a special charging system is used whereby it is possible to charge a set of completely discharged batteries in less time than is required to discharge these same batteries under load. In this way continuous 24 hour operation is assured. It is customary to operate two re-

cording channels from common "A" and "B" batteries. Fig. 8 shows a view of the Battery Room.

The use of concealed gutters or ducts in the floor of the Recording Building rather than conduits as shown in Fig. 5 facilitates the installation process and at the same time provides for any possible future wiring requirements. It also makes an especially neat looking job.

In a general way, methods of sound proofing are much the same in most of the studios with which we are connected. First, there is an outer shell of hard non-porous material such as concrete, tile, or simply metal lathe and gypsum plaster. Attached to the inside of this outer wall studding are one or more layers of gypsum plaster-board, and two or more layers of sound absorbing material, such as masonite, celotex, cabott's quilt, insulite, flaxlinum, or other materials of like properties, each layer being separated by studs or furring strips and the studs staggered. A maximum of air space is allowed between. Then, there is an inner wall usually separated from the outer shell by an air space varying from about 5 inches to 30 inches. In some cases this inner shell is supported upon a foundation which is entirely independent of the foundation for the outer shell. In those cases where a separate foundation is not used the floor joists are carefully insulated from the piers or foundation by such material as celotex, cork, or felt. In some cases the piers for the floor joists are supported on sand in order to insulate the floor from shocks in the vicinity being transmitted through the ground.

The stage ceiling may either be suspended by well insulated supports from the roof or may be entirely free from the roof and supported by the inner shell of the stage.

Figs. 13 and 14 have been included to show the methods of sound proofing and acoustical treatments used in some typical

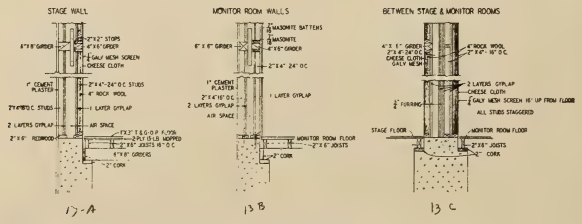


FIGURE 13.
Typical Sound Proofing and Acoustical Treatments

studios. It is, however, beyond the scope of this paper to discuss their relative merits.

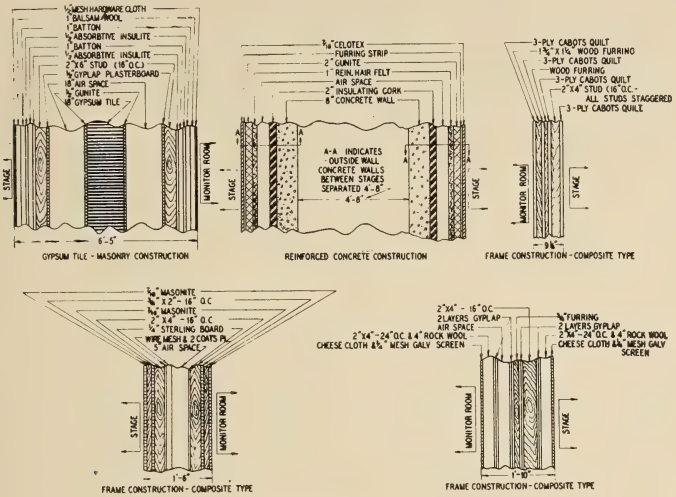


FIGURE 14.
Typical Sound-Proof Stage Walls

The typical sound studio recording installation of today is the result of a few short years' experience in the commercial application of the art of sound recording. It is inevitable that marked improvements will be realized as new and better methods are developed. The typical installations which I have referred to are even now in a state of transition and tomorrow may witness major changes in the physical aspects of the work. The need for sound recording facilities, has, however, been so firmly established and the results have been so satisfactory to the public that a certain future is assured for this important business.

DISCUSSION

MR. CRABTREE: What is the maximum number of microphones that have been used on a set in New York or Hollywood? What is the operating range, and what is the distribution curve for a microphone? That is, when placing the microphone at varying angles from the normal in relation to the speaker, what is the distribution curve for a given sound intensity? Also, what does the monitor man do? Is he really necessary? If you left him out would the music be better than what we get now?

MR. HUMPHREY: I couldn't say what the maximum number of microphones which have been used is, but one may use as many as are thought necessary. Some producers have made provision for the use of as many as nine transmitters and others have put in facilities for only three. The Mixer Man decides how many microphones will be used to pick up a particular set.

With regard to the distribution curve of the microphone, I do not know of any curve on this. In general, if the speaker talks directly towards the transmitter you will get the maximum number of high frequencies. If he turns away from the microphone you get a loss of high frequencies and sibilants, resulting in a muffled effect.

I think the Mixer Man is important from the sound standpoint. He corresponds to the camera-man in a picture. It is up to the Camera-man to obtain the best picture he can while the Monitor-man is responsible for obtaining the proper acoustical treatment of the sets and to balance the voices of the artists or the instruments of the orchestra. If the Mixer-man is working on a scoring stage he should be a man of musical ability and have good judgment of sound quality. He need not necessarily be a technical man. I believe the Mixer-man to be the most important individual in the Sound Department, because of his judgment on acoustical matters and sound quality.

MR. EDWARDS: I would like to ask Mr. Humphrey: He spoke of the monitor man arranging his apparatus so as to accommodate an average of acoustic reception in various theatres. I should like to know how that average is arrived at. It seems to me that the variance is so great in the majority of the theaters that an average one would not suit all of them.

MR. HUMPHREY: If you listen to the output from the microphone in a loud speaker having similar characteristics to those used in the theatres; in a monitor room having dimensions such as I mentioned in the paper, we have found by experience that most of the productions thus made will sound satisfactory when reproduced in a theatre. To approximate the acoustics of the larger theatres it might be desirable to go to larger monitor rooms.

PRESIDENT PORTER: In view of the interest expressed in the discussion on monitoring, I should like to mention that we have a paper on monitoring by Mr. Tuttle of the Famous Players, and it might come in after this paper. I ask this because Mr. Tuttle has

to go away on location, and if we don't have the paper shortly, we won't get it. Is that satisfactory to Mr. Woodward?

Dr. E. Cook: While the author of the paper was going through his work I was considerably perturbed by the expense of such a layout. It looks terrific, and I think the only way in which it could be justified would be by the sound pressures of the room. I wonder if the author could tell me what the sound pressure is and how necessary this tremendous expenditure is to the producer and the listening public.

Mr. Humphrey: I am not prepared to go into a discussion of acoustical treatment or sound proofing. I am sorry that I have no data on the sound pressure in dynes per centimeter squared at the microphone. It is generally accepted and fairly well known that if, for example, you are scoring with an orchestra of about thirty instruments, you must have a fairly large studio. However, it is usually the picture requirements which determine the minimum size of the stage. Producers have experimented with different degrees of acoustical treatment. Some studios are quite dead while others will be found to be fairly live. Acceptable results seem to be obtainable on either.

Dr. E. Cook: I mean sound-proofing and not sound-deadening; the transmission from one studio to the next.

Mr. Humphrey: I do not know how far you can cut down on sound-proofing. I do not think any thing is 100% sound-proof. It is a compromise as to how much expense a producer wishes to go to in order to insure against extraneous noises getting into the studio. There are some stages which are not treated for sound proofing at all. In such cases they have to stop traffic outside the door while recording or else the recording work is done at night when there is less interference from outside noises. On one lot in the East when they are recording in one studio it is necessary to stop work in all the other studios because of the noises conducted through the building from one studio to the others.

Mr. E. Richardson: Perhaps somewhat in sound we are making the same mistake made for many years in other things—working hard for something and then ruining it for the public. I have told the director of one or two big companies here the same thing. I think some energy might be spent by some of the large producing companies in preparing matter for architects who will build theatres. They can't obviate errors of the past, but they can

in the future avoid what is ruining the effect in many of our theatres. A standard of acoustics could be set up, but architects don't understand that, and it is one of the duties of the industry which it owes itself that the most possible should be done. I think a great work could be done in that direction, and the sound producers owe it to themselves to educate the architect.

THE ART OF MONITORING

C. A. Tuthill*

THE qualifications of a monitor man are far greater in scope than is generally conceded. They include practical experience and a generous knowledge of subjects never touched upon when this individual is discussed openly or otherwise around the movie lots. His work has a definite relation to engineering, yet he is not wholly engineer; it has a perpetual relation to photography, yet surely he is not a photographer; most certainly it has an inseparable relation to acting, and just as certainly he is not an actor, though directors frequently call him a bad actor. He is not a mechanic. He is not a freak. He is merely a human being with a past—that is to say, his past experience makes him what he is today and fits him for his job. In fact, the value of a monitor is determined by his training prior to the advent of the Talkies plus his ability to apply himself. The man under discussion cannot be born over night nor can he be developed in a week or a month.

This discussion deals only with a monitor man of the highest calibre, and these are not very plentiful, as any recognized recording or broadcasting studio will testify. He must have the brain of an engineer, but the heart of an artist. He needs enough engineering to give him a thorough understanding of all the electrical equipment involved, its response, its weaknesses and its action upon the finished product. He should be familiar with the science of film development and printing; have a general knowledge of what takes place in the laboratory. He must have a good working knowledge of acoustics though he must not take this matter too seriously. He must be flexible enough to lend his art to all occasions, as every new set-up involves new acoustics, and other problems, differing from the preceding shot. For example, when three camera booths are moved in for a close-up, the acoustics are radically changed. He cannot theorize. He must apply methods which he knows produce definite results. He cannot experiment, at the expense of a production, to prevent distortion; he must know what to do to prevent the distortion. He cannot apply the slide rule, nor can

* Paramount Famous Lasky Corp., Long Island City, N.Y.

he assert positive limits. He must be capable of adapting his facilities to his problems. While his limitations bear a definite relation to engineering, they also bear as great a relation to photography and action. Therefore, his limits are determined only by himself; and hence if he be genuine, he is very definitely an artist.

Whether the material under his control be music or dialogue, he must contribute a sense of appreciation for values. He must have a feeling for that which is to follow and be able to anticipate whether the material will continue constant or grow more piano or more forte. At the same time, he need be constantly careful that he does not check or re-touch the softer or louder passages except where essential. Similarly he must not suppress latitude.

He must apply his methods, and this includes proper placement of microphones, in such a manner as to allow the actors as much freedom as they are allowed by the cameras. He must not interfere with good photography. By proper cooperation with the director and cameraman he can work out methods which will net as fine a picture as would be possible, were the same subject being shot without sound. He must recognize production values both in picture and action, and devise a means for procuring a good recording without destroying the value of a spacious and beautiful set. If the scene be of a rough or delicate artistic value he must contribute a quality of appropriate sound. A perspective of sound in keeping with that of the camera is desirable in spite of the fact that optical illusion and lip reading somewhat correct for differences in volume. The placement of microphones is an art by itself, not to be discussed in this paper.

The monitor man must have vision. He cannot think only of the present. He must consider the possible changes which, occurring within the next two years, will directly affect his finished product. For example, thought must be given to the influence upon his recording of a change in projection equipment. It is reasonable to believe that any general improvement in projection will bring out greater definition, and that the trend will be to sharpen the sound. Then, the monitor need be careful that his offering is not shallow.

There have been some very poor recordings turned out by really genuine monitor men. The fault has not been theirs, nor is this traceable to any one thing or person. Producers and their

directors have not had available information, proven to them to be bona fide and upon which they could rely. They have, however, been too often misinformed, and hence their confidence in their sound men has not increased.

A monitor should know much about the actors and actresses he is going to handle. Actually, he does handle them not only by the aid of a few knobs, but through direct contact, and in this he cannot always be persuasive. He must know the life they live, their thoughts and habits; he must speak their language. In this phase of his work he must be careful not to offend his director. In fact, a greater co-operation between these two men, plus a better understanding of each for the other's work, will do much to improve the Talkies. Some directors and some producers already realize the value in that last statement, but unfortunately, these are still in the minority.

Those monitors who find themselves in association with a director who knows the speaking as well as the silent drama, find themselves nicely situated. Others, however, are assigned to the staff of directors who have had only motion picture experience or who have had only that of the speaking stage. In either case, the technique formerly employed by the directors must be modified or replaced, and the change which is necessary can only be determined as these men take the sound men into their confidence.

DISCUSSION

Mr. Crabtree: Do I understand that the monitor man has it in his power to (a) change volume, and (b) to mix the music from different microphones in different proportions? In the case of a single microphone, why is any modification necessary? You say you can change the "tubbiness" of the sound or music; how is this done? Is the monitor man responsible for the positioning of the microphones? Also, has the experiment been tried of using sound absorbers in closer proximity to the person than the wall of the room? In the case of an orchestra where you have four or five microphones, is it in your power to put on more bass or cornet and so on, and if so where do you and the orchestra conductor fit?

Mr. Tuthill: That last question is so interesting, we will take it up first. There has always been co-operation between the conductor and the monitor. I refer to either broadcast or record-

ing studios, and from there we have gathered our past experience. The orchestra leader calls for his pianissimos and fortissimos; having set up the microphones we balance the orchestra. In the case of a symphony, we would ask the conductor to come in with us. In musical recordings in the motion picture game, we bring in something which the former director steps aside from and leaves to us, and we accomplish the best results by co-operation with the orchestra leader himself. Again, there is the point that the monitor man cannot be merely a musician. If he knows all the instruments and symphonic arrangements, he will have great difficulty in satisfying the leader of the orchestra he is recording; because the monitor is liable to lend his own interpretation to the music.

With regard to the placing of the microphones: this depends on the policy of the company with which you are connected. My Motion Picture experience has been with only one company, and there the monitor man has the authority to O.K. or N.G. a "take"; but he must not abuse the privilege. He also places his own mikes. In a picture we have been working on, which reeks with drama, some of the "take" is good and some is not. It is almost impossible, when handling such heavy material, to get 800 or 900 feet which would satisfy the director when he sees the rushes. We don't throw out such "takes," but hold on to them, cut them up, and splice them together. This is done in such a way that you will never know that it is not one recording; there is no fluctuation or change in quality. There again, placing of the microphones has considerable to do with that.

With regard to reflection and absorption. The installation of baffles and such along the edge of the set must be done in some cases. There again acoustics enter into it, and set construction means much.

We may have a set at the end of a long room. If it be a sound stage, there is little worry. If we build the set on one end of the room and use possible only a third, and the rest is unoccupied, the trouble would be serious. In that case, we would use drapes or the sound "goboes" until we obtained the desired effects. The case of working on a much larger stage, such as those not originally designed for sound, brings in plenty of problems.

A subway is being put in three blocks from our studio, and I imagine we shall have blasting, and we are shooting on an open

upper stage with no partitions except the cloth ones so that we have good reason for more soundproofing, and if it is like Eighth Avenue, we shall go out of business for a while. If you have heavy traffic and things of that sort, microphones not carefully isolated from them, will give trouble. By the use of proper draping and so forth, we can do an excellent recording without a sound stage, if everything else is ideal; but if an airplane flies by, the "take" is ruined.

PATENT PROBLEMS IN BUSINESS

F. T. Woodward*

AT THE risk of boring you, if you know more about my subject than the usual gathering, even of engineers, I will approach my subject from a historical standpoint. How frequently we hear of businesses and industries which have been founded on patents. They range from telephones to safety razors, from air brakes to garment fasteners. In countless industries patents have been an important factor, if not the most important factor, in determining the growth and success of the business.

So we are not surprised when we learn that the business of patents themselves, that is, their solicitation, their examination and grant by the Official Patent Offices and the commerce in patent rights and licenses, is in itself in the nature of a gigantic industry. Those who practice in it are no less specialized than the specialists of the other industries in spite of the fact that their specialization is frequently of a double nature, that is to say, specialization on one hand to that branch of the law relating to patents, and on the other hand specialization in some particular line of industry, as for example communication.

Whether or not the industrial and business expansion of this country since the Civil War was made possible by our Patent System as has been argued, the fact remains that the expansion and development of business and of the patent system have gone hand in hand and have been and are dependent upon one another.

Considering, therefore, the size and importance of the patent system, and the matter of fact way in which we accept its more or less vital importance to business, it may or may not be surprising to find that the patent system is the outgrowth of the necessities of business. It is in fact one of the first and most enduring of the results of business expansion when business as we now picture it was first stirring out of the bud of purely individual effort into the complex interrelation and co-operation of effort which is business as we know it today.

In those early days, even as today, there was no necessity or compulsion on the inventor to disclose his invention to the public.

* Electrical Research Products, Inc., New York, N. Y.

For an invention of such a nature that it may be kept secret while being worked, the scope of the inventor's monopoly is limited only by his inability to maintain it secret. Inventions of this type, although extremely rare, undoubtedly do exist, and certain types of higher craftsmanship undoubtedly have depended upon inventive secrets passed on from father to son throughout generations.

It is quite apparent that back in the days of purely individualized industry, many forms of activity lent themselves admirably to the working of secret inventions to the small but satisfactory profit of the inventor. When, however, craftsmen began to reach out to cover wider markets, or to hire help to supplement their own labor, the maintenance of secrecy became more and more difficult. How the first patent came to be granted I do not know, but it may very well have been in some such manner as follows: When the miller who ground more and better flour because of his improved water wheel, or grinding gear, was threatened by his overlord with dire punishment if he did not impart to a miller in another portion in the lord's domain the secret of his success, both being reasonable men, a contract was struck. By this contract the inventive miller was given certain rights of one nature or another in return for his disclosure of what he had invented.

Assuming the illustration given to be the first such event, we can say that this contract represented the first patent, for exactly the same thing in principle takes place, save only that it is without compulsion other than of economic necessity, when the present day inventor discloses his invention to the Patent Office and the Patent Office issues him a patent thereon. Of course the form of compensation, so far as the patent is concerned, has now crystalized into a definite thing, that is to say, a monopoly for a certain number of years, with respect to the thing invented.

Now this word monopoly brings us to another point that we should understand. Back in the latter middle ages when kings were more autocratic and absolute than they are today, it was quite good form for the king to grant to some favorite the sole and exclusive right to supply his subjects with some necessity of life. Obviously this was very nice for the favorite but was rather rough on the subjects; for the favorite could not only charge any price he liked, subject only to the king's change of mind, but he could decline to supply *at any price* if he so desired. These grants were called monopolies and the documents by which these grants were

effective were called Letters Patent, and Letters Patent is still the "high hat" name, used in such weighty documents as Bills of Complaint, etc., for what we know commonly as patents.

Now we know, or at least we think we do, that patents relating to inventions, are a good thing and for the general good; but because they were granted in the early days in the same way and by a document bearing the same general name as the iniquitous monopolies in necessities of life, they got into some very bad company. Curiously enough, this evil reputation persists here and there even to the present day. The most notable and outstanding evidence of this in recent years, was the abolition of the Russian Patent Office by the Soviet Government, which abolition was based solely on the alleged Soviet abhorrence of the word monopoly and all it stood for.

During the reign of Queen Elizabeth, these patent grants or monopolies became particularly numerous and odious. Leather, salt, coal, fish, oil and many other commodities, as well as the right to practice certain trades or businesses, were made the subject of monopolies. It is said that Sir Walter Raleigh enjoyed the exclusive right to manufacture and sell playing cards. The situation became eventually so intolerable that in the reign of James I, the so-called "Statute of Monopolies" was enacted. This statute is generally considered as the foundation stone of Anglo-Saxon patent systems for the reason that while abolishing all other monopolies, it excepted monopolies founded on Letters Patent of invention, which might be granted under certain terms to persons who introduced new manufactures into the realm.

With regard to our own patent system, its basis is specifically to be found in the Federal Constitution in that provision which states that Congress shall have the power to promote the progress of science and useful arts by securing to inventors, for limited times, the exclusive right to their discoveries. Laws have been enacted from time to time by Congress in pursuance of the power thus stated, and the granting of patents is a purely federal matter, being one of the powers reserved to the Central Government and surrendered by the States.

A patent, as we have seen by the illustration given, is in the nature of a contract between the Government and the inventor, whereby in return for a full disclosure of the invention, so that sub-

sequently others may be enabled to work it, the inventor is granted an exclusive monopoly to practice his invention for a limited period, after which limited period the right to do the thing covered by the patent becomes public property.

In this country patents are issued by the Government for a period of 17 years, and the exclusive right begins to run when a patent is issued. When issued an original printed copy with the seal of the Patent Office is sent to the patentee, and at the same time other printed copies are made and thereafter distributed at a nominal price to those who may desire them. Considerable confusion exists even among those who have to deal with patents, but who do not specialize therein, as to the meaning of the "Exclusive" right granted by a patent. No patent is necessary to give the inventor the right to practice his invention, nor does the exclusive right given by the patent grant him an absolute right to practice his invention. The patent is merely the right to exclude others from practicing the invention, and the inventor by applying for, and obtaining a patent, obtains not a greater right to practice his invention than he had before, but only the right to profit in his trade or industry by preventing others from practicing his invention while the patent is in force.

To explain what is meant by "Exclusive Right" or rather the right to exclude which is secured to the patentee, I will quote an example:

Suppose we are living in an age when chairs are just coming into use and inventions are being made in that art, and suppose that you had secured a patent covering the novel idea of a chair having a seat, legs and a back. You establish a factory, advertise your new and useful article and sell it everywhere. Your business is just getting a good start when I, having seen one of your chairs, conceive the idea of a valuable improvement in it for which I apply and obtain a patent. My improvement consists in adding arm rests to your chair so that my chair now comprises a seat, legs, back and arms. You will see that I have taken your article retaining all of its elements, merely adding to it the arms, and making it, we will say a more salable article. The government has granted to you the right to prevent others from manufacturing chairs having seats, legs and back, and to me the right to prevent others from manufacturing chairs which may be like yours but with the added arms. You will readily foresee the failure of any attempt I might make to

manufacture my article, for the whole structure covered by your patent is found in my chair, and you can therefore exclude me from manfacturing it. Likewise, I can exclude you from manufacturing your chair with the arm rests of my invention added to it. Consequently, neither of us can manufacture, use or sell without license from the other party the article patented by such other party. The situation soon arises that many of your customers, knowing of my arm chair, are not content to buy your article with merely a back, and you soon see that even though I cannot manufacture the complete arm chair because of your patent, my exclusive right to manufacture arm chairs is of some value. Like the miller and his overlord, being reasonable men, you and I therefore determine to exchange licenses so that we can both manufacture chairs which will be satisfactory to our customers.

Again, suppose after such exchange of licenses had been effected we make an investigation of the Patent Office records. We find that another party had previously obtained a broader patent than either of ours, his patent, we will say, covering a chair with seat and legs, that is to say a stool. This third party can exclude both of us from continuing the manufacture of our chairs and if we are to continue the manufacture of our chairs, without fear of molestation, we will have to pay tribute to the owner of that basic stool patent.

Consider another aspect of this situation. Suppose now the basic stool patent, that is, the one covering broadly a seat with legs, has expired, but your patent for a chair having seat, legs and back is still in force. I, knowing of your patent but having a desire to go into the chair business and finding you unwilling to grant me a license under your patent, consider carefully the matter with a view to finding out how your patent can be avoided. I can, of course, make stools because the right to make this article is now public property, but this does not appeal to me. I wish something more on my chair than the seat and legs. I cannot put a back on it because of your patent, but my prospective customers demand something more than a stool. At this point I conceive of the idea of placing arms alone on the chair, omitting the back. The article produced may not be as good as your chair with the back, but I believe that it is a salable article and I go into the business of backless chairs, but with arms. You cannot exclude me from this business, because I have omitted one of the elements of your invention, to

wit, the back of your patented chair. I may even get a patent claiming a chair having a seat, legs and arms for I have produced a new combination including, it is true, two of the elements of your chair but adding a third, the arms which you did not have, but which are new in the art, or at least had never before my invention been used on chairs. Although you were the first to put any kind of upright support on the seat of a stool, making a chair of it, you limited your patent to a chair with a back and can therefore only exclude others from making that specific combination. The realization that you might have worded your patent less narrowly and obtained one for a seat, legs and we will say an upright support on the seat, comes too late.

This last illustration suggests that the patenting of inventions is an extremely technical proceeding. This is unquestionably true, and while the Patent Office rules permit the inventor himself, if he so desires, to solicit his own applications for patent, nevertheless it advises the inventor to employ a registered Patent Attorney, that is to say, one who is presumed to be skilled in the preparation of the patent application and the further solicitation of patents.

Not every valuable improvement is patentable. For example, one may develop a new method of conducting business or a new system of keeping records, or of bookkeeping or running a sales campaign or may evolve a new theory of matter or electricity. For improvements along such lines patents will not be granted. Furthermore, an inventor of something patentable may lose his right to a patent, as by delay in completing it, or abandonment or by failure otherwise to apply for a patent in due time. Furthermore, the application for the patent must be in the name of the actual inventor thereof, and again, it is obvious he cannot patent a device known or used by others prior to his invention merely because at the time he made the invention he was unaware of such previous knowledge or use.

Assuming, however, that having made the invention, you have the good sense to submit it promptly to a qualified Patent Attorney, we will not concern ourselves further with the details of an application and other procedure necessary to obtain a patent, and I will confine myself for the few minutes left to me to a discussion of the three classes of problems which I referred to in the beginning, and which may be grasped very briefly if you have followed with me so far.

The great majority of the Problems relating to patents which arise in business may be divided into three classes which I will call the Problems of Protection, the Problems of Rights, and the Problems of Validity.

Protection

Whether you are establishing a new industry or are busily engaged in a hotly competitive industry, any new apparatus, device or method which you may develop and by the use of which you may obtain a more or less decided advantage over other manufacturers, or your competitors, will be very valuable to you if you can retain it solely to yourself. Consequently, the protection of the invention may be of very great importance. Of course you may be able to defy competition, keep your invention secret as long as you can, and then let your competitors have the benefit of it. Some business concerns act on this policy; but the general conviction is to the contrary, and since you have been provided with the means to secure this protection, and, generally speaking, at very nominal cost, you would be very foolish if you did not take advantage of it. Furthermore, by promptly applying for and obtaining a patent you may obviate the situation wherein some other worker in the same art or industry has made the same invention and, you having failed to apply for a patent, the patent which he obtains may be very embarrassing to you.

Let me advise that, whatever may be the ultimate decision in regard to applying for a patent on new things you may develop, when you think you have made an invention, make a record of it, and by a record I mean a written sketch or description, or both, sufficient to set forth clearly, but not necessarily elaborating, the thing which you think you have invented. Having made such record, explain it to someone whom you can trust and have that person write on the face of the record "Witnessed and understood by me this ————day of————," and sign this statement. With this kind of a record in his hand, your attorney, assuming that there has been no undue delay, will be in a position with a minimum of difficulty to obtain all the protection to which you are entitled. So much for protection.

Rights

When you start out to manufacture a new thing or exploit a new

process, I think you will understand from what has gone before, that it is not sufficient that you have improved on articles and processes already on the market or in use, or even that you have obtained a patent on such improvement. Consequently, whether or not you have improved on what has been used previously, you will have to determine whether you have a right in view of patents already issued to do what you propose to do, and you will therefore have your attorney make what is known as a "right to use study." You will place before him the thing you want to make, or full and precise information about what you want to do, and the search will be made by him of the patents already granted in the art to which your industry relates to see whether the thing or process or any of its parts are covered by unexpired granted patents. If the study has been a good one, and no patents have been found which you would infringe upon, you are reasonably safe in going ahead, although of course there may be interesting pending applications in the Patent Office of which, your attorney is unaware, since applications are maintained strictly secret up to the time of the actual granting of a patent.

Suppose on the other hand, that your attorney finds outstanding patents having more or less bearing on what it is you propose to do. Depending on circumstances, you may decide to try to acquire rights under such outstanding patent or patents. These rights may take the form of purchase of the patent, that is, the assignment thereof to you, or a license which may be exclusive or non-exclusive, the meaning of which terms I think will be obvious. A license may also be qualified in other ways, that is to say, you may obtain a license to do certain things and not others, or to manufacture and sell in a certain portion of the United States and not in other portions. In any event, the acquirement of rights in this way is a matter of negotiation, and if you have clearly in mind what is the minimum that you require and the maximum that you will pay for it, you should have no difficulty either in negotiating the rights you require or in learning if it is impossible so to do.

Suppose, however, that your attorney has reported to you that there are certain outstanding patents which cover parts of your proposed article or process, but do not cover it as a whole. You may consider that you have done some real inventing before this time, but after you have tried to redesign your article so as to avoid these patents, you may decide like the colored brother in the story,

"you ain't seen nothing yet." Nevertheless, this is very commonly done. After a patent study, which does not show that the patent situation is entirely hopeless, redesigning to avoid outstanding patents may not only serve to free your article or process from their domination, but may also result in an improved article or process. In exercising your imagination to discover equivalents, in a practical sense, which will not be covered by the patents in question, your knowledge of the art in which you are dealing may be so broadened as to be of positive advantage to you.

Under this heading I suppose I should discuss infringement, not overlooking the even more subtle subject of contributory infringement, but I do not believe it would be feasible so to do with the time at our command, and I will only take the opportunity to negative the popular misconception of the law with regard to infringement which has to do with the making of a patented article or the use of a patented process for one's own personal use. Whatever may be the popular idea, the patent monopoly gives the right to exclude others, without qualification, from making, using or selling the patented invention, and while a patentee may never hear of your use of his invention, or hearing of it, may decide that it would be a waste of time, money and effort to sue you, nevertheless, you are an infringer, and, in due course if he sees fit, he can obtain an injunction against you coupled with an award of damages or profits as the case may be.

Validity

Validity problems arise in connection with both protection problems and right-to-use problems. A patent is said to be prima facie valid. The Patent Office in granting a patent on an invention does not guarantee the validity of the patent. It does, however, endeavor to give the patentee a good patent by the examination of the application by experts in the Patent Office, who work with the applicant's attorney, principally by correspondence, but sometimes in personal interviews, to the end that the patent may be issued to the first inventor for a novel and useful improvement.

It is upon this examination that we say that the patent is prima facie a valid patent. In view, however, of the many thousands of patents which are annually being granted in this and other countries and the many technical and trade journals which are published, it is not to be expected that the Patent Office can turn up all of the

so-called anticipations that may exist. When, therefore, the time comes that the necessity arises of bringing suit against a competitor, in order to maintain the protection to which you think you are entitled, the question of validity of the patent, upon which it is proposed such suit should be based, is of very primary importance in order that time and expense may not be wasted, and disconcerting surprises met with in the trial of the action. Correspondingly, when a patent has been found or has been brought to your attention that on its face would interfere with your making or doing something which you had set your heart upon, and which may be of very essential importance to your business, the matter of validity of the patent in question is not to be lightly accepted and a determination of the probabilities of the result of litigation on this patent must be undertaken. The consideration of a patent from the standpoint of validity is a highly technical and difficult job. Ancillary to the question of validity, the patent claims are to be considered to determine whether their scope is sufficient actually to dominate the thing you want to do, and even this determination involves the consideration of the so-called "prior art"—to learn the meaning of the terms used in the claims and how broadly they are to be construed. Assuming that they may properly be construed of sufficient breadth to be of interest to you, the main question of validity arises: to see if they actually comply with the statutes with respect to "patentable novelty."

Obviously, the first thing to do is to make a very thorough search of all patents of similar nature and of the various publications which might disclose things that have been done by others along the same line prior to the invention covered by the patent. It is apparent that there will seldom be found any exact anticipation, and the real difficulty arises when the question of invention in the claims of interest over these anticipations must be settled. Honest differences of opinion will undoubtedly arise, and for this situation there remains no solution except the determination by the courts.

I regret that I have been able only to touch so lightly on the actual problems which arise with respect to patents in the conduct of business, but no general rule can be laid down as to how any of these problems should be handled. It has been pointed out that the problem of validity is only another angle of the problems of protection and right-to-use respectively. Each problem will have its own

variations and its own peculiar set of facts, and can only be determined on its own merits.

If, therefore, some of you have learned something of the nature of patents that you did not know before, and something of the difficulty with respect to patent problems which may impel you to take due care with respect thereto and obtain qualified advice when they do arise, I shall be more than satisfied.

DISCUSSION

Dr. Hickman: I was talking the other day with a patent attorney, and he told me that during the past ten years a very great change had come about in the kind of material patented. In former times, patents were secured on things generally having inventive novelty, but now we see chiefly patents of design. Manufacturers are forced to put in complicated patents of design, because otherwise people may prevent them using their own developments. This patent attorney suggested that there was only one way out of the difficulty and that was to form an industrial code of ethics as to what was useable of another man's design; otherwise, the amount of money spent would be out of all proportion to the benefits accruing from small apparatus. Is this code of ethics practical?

The second question was supposing that during the progress of any design a perfectly adequate signed up record is kept of the different steps. Will that be sufficient for evidences of priority in a court of law?

Mr. Woodward: With regard to the code of ethics, I think the best answer I can make is to tell a story about a farmer who, just getting back home from a Grange meeting, tells his wife, "We determined that we would all restrict the acreage 20 per cent this year. You just wait until you see how I fool them!" A code of ethics would be fine if everybody stuck to it, but I don't think it would stand the test of business competition.

With regard to the second, no, that wouldn't be an anticipation. It must be a public use or sale; it must be a printed publication or a patent. The record to which you refer is of assistance in getting your patent or in fighting an interference proceeding. You can establish priority best with that kind of a document provided that the people interested can testify to support it and that they

can recall the actual things that were done instead of merely the idea recorded, but you can't use a record of what you did as a defense on infringment.

Dr. Hickman: With regard to the anticipation by publication, one has heard of inventions which were described in obscure foreign journals which the probable user would never see. That does not seem to me a fair form of publication.

Mr. Woodward: The question is this: Does the public get the benefit of the invention? A patent is for the benefit of the public after seventeen years. The record you refer to would never get to the public. We do run up against just the sort of thing you mention. In Germany we were thrown out on a certain case recently by the work of an obscure Italian engineer working in his own laboratory; he did some original work during a strike and published it in his local engineering publication, and this was held to anticipate and bar our patent application.

NEED FOR IMPROVEMENT IN PROJECTION EQUIPMENT AND MAINTAINANCE

F. H. Richardson*

IN THE days of Pharoah in the making of brick, straw was necessary and when straw was denied the Hebrews, they could not make brick, not withstanding the demands of the King. Today many exhibitors of motion pictures are demanding high grade results upon the screens of their theatres, and at the same time failing or refusing to keep their projection equipment either up to date or in a good state of repair. They apparently do not know that it is just as impossible to produce high grade projection results with old equipment in a poor state of repair, or even with up to date equipment in poor condition, as it was for the men of the time of King Pharoah to produce bricks without the necessary straw to bind the clay together.

One of the unfortunate results of the early days in the motion picture industry was that men took up the exhibition of motion pictures without even the most elementary knowledge of, or training in the show business. This condition was primarily responsible for the unfortunate, not to say absurb idea prevalent then and later, that the manner of the display of the finished product of the industry before the buying public, called then as now, projection, was of small importance. Because the exhibitors of those days knew nothing about the show business, it was not to them a matter of how well, so much as it was how cheaply could the picture be projected.

It is a rather sad fact that once an idea has become well rooted in practice, no matter how wrong or how harmful it may be, it is a very real task to uproot it and substitute better ideas.

The producer, then as now, expended every possible effort in the endeavor to supply productions of real merit, but there his interest and the interest of every one else seemed to cease. No one, including the producer who had worked so hard and expended so much money to perfect productions, apparently had the slightest interest in how they appeared to theatre audiences.

* Exhibitors Herald-World, Chicago, Illinois.

Directors would spend perhaps hours and hundreds of feet of negative film in an effort to secure exactly the effect sought in a scene,—for example a death bed scene—which in a very large percentage of the theatres of that day was jammed through the projectors at a speed which made the so carefully planned scene into a farce comedy in which the actors moved about like animated jumping jacks; and the queer thing was that no one seemed to have the slightest idea that anything wrong had been done.

The men placed in charge of the reproduction (projection) of productions were not recruited from the standpoint of ability, but from the viewpoint of cheapness in wages. Every improvement in

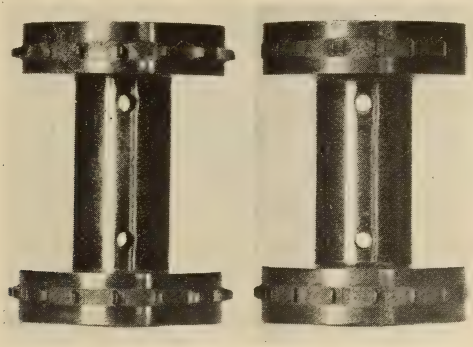


Fig. 1.

projection equipment which meant a rise in price was complained about and discouraged. In short, in the early days, largely because of the reasons I have set forth, projection labored under pretty nearly every handicap imaginable; and it is a rather sad fact that recovery from the evils established in projection practices by lack of knowledge of the show business is still far from complete, as I shall endeavor to show you before I have finished.

As will be remembered by many of you, the producers of early days expended large sums of money and great effort in the finally successful effort to secure mechanical precision in sprocket hole punching. No effort and no expense was deemed too great to secure that high degree of accuracy necessary to the projection of a steady picture upon the screen.

The joke of it was, and still is however, if so very serious a matter can be termed a joke, that after perfection finally was at-

tained, those perfectly punched sprocket holes were, and still are, not at all infrequently sent out to make personal acquaintance with what we see in figure 1. And, gentlemen, permit me to assure you that what you look upon is not merely a prepared "horrible example." Incredible as it may seem to you, it is the photograph of intermittent sprockets removed by a projector manufacturer to whom the mechanisms had been sent by an exhibitor for repairs.

"Impossible" do you say? Calm yourselves, gentlemen! I shall show you very, very much worse examples before I have done. The extent to which projection equipment is permitted to fall into a state of disrepair which makes really high grade results upon theatre screens impossible, is nothing less than astounding, although

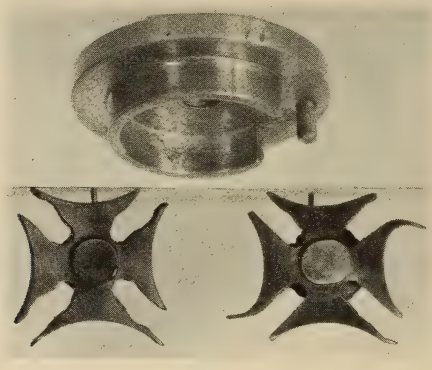


FIG. 2.

it is true that it is not as bad as it once was.

The motion picture industry began to take on the form of theatrical amusement in the year 1896. It therefore is something more than thirty years of age. In these days of speed, thirty years would seem ample time to learn the simple fact that it is utterly impossible to have perfection in the performance of any mechanical device in which mechanical perfection of functioning is measured in ten thousandths of an inch, if replacement of worn parts is delayed until the wear amounts to a great many times that measurement.

Taking the projector intermittent movement as a convenient, easily understood example, we all know its functioning parts must be formed and shaped by delicate grinders running at terrific speed, until they will fit together with a tolerance of less than one ten thousandth of an inch. We know this must be done if the move-

ment is to function with the accuracy necessary to put an acceptably steady picture upon the theatre screen.

Asking you to remember the required high degree of functioning, and the very great accuracy of fitting the intermittent movement of the modern projector must have and does possess when it is new, I invite you to take a good look at two "stars" and a cam which were removed from projector mechanisms sent to one of our leading projector manufacturers for repair.

These parts are exactly in the same condition they were in when taken out of the mechanisms, except that I believe the points of one of the "stars" were bent after removal. Ridiculous and ununderstandable as it seems to us, a so-called "exhibitor" actually placed the productions he rented from producers before the patrons of his theatre using these parts. I also invite your attention to the cam worked in conjunction with one of these stars. Observe the deep groove worn in the face of the cam ring. It is well nigh beyond belief that these parts would or could function at all. I am uncertain as to whether the bent star points were not bent when the star finally locked with the cam pin and refused to work further.

Of course it is not intended to convey the idea that any considerable number of theatres are using equipment in such utterly wretched condition as is indicated by the parts I am showing. As a matter of fact, I have picked out a few "horrible examples"—the worst I was able to find, just to illustrate the possibilities for abuse, and also that such parts as I have shown you are actually used in practical theatre projection. The fact remains, however, that even at this late date, relatively few exhibitors maintain their projection equipment in what could, by any stretch of imagination, be called perfect condition.

Exhibitors, taken as a whole, are still a long way from realizing the importance of maintaining their projection equipment in as nearly as possible perfect condition. A still smaller percentage of them realize the fact that the constant improvement in motion picture projectors, and other projection equipment, increases efficiency in operation and excellence of results far more than enough to justify keeping their equipment up-to-date. They have yet to learn that the demand for accuracy in mechanical parts is such that a projector part may be condemned before there is sufficient wear to be visible to the unaided eye. In fact, in certain parts, wear sufficient

to be discerned by the nude eye would or should condemn it as being long past the point of functioning well and efficiently.

Many exhibitors apparently do not yet realize the fact that insofar as "shows" are concerned the industry functions more or less as a whole, because the films must perforce be used by many theatres.

This being true, it follows that any damage done to the films in one theatre must and will react to the injury of the show in every theatre in which they are thereafter used. This is something no theatre may escape the consequences of, because no theatre, first run or not, may hope to use only films that were never used by any theatre.

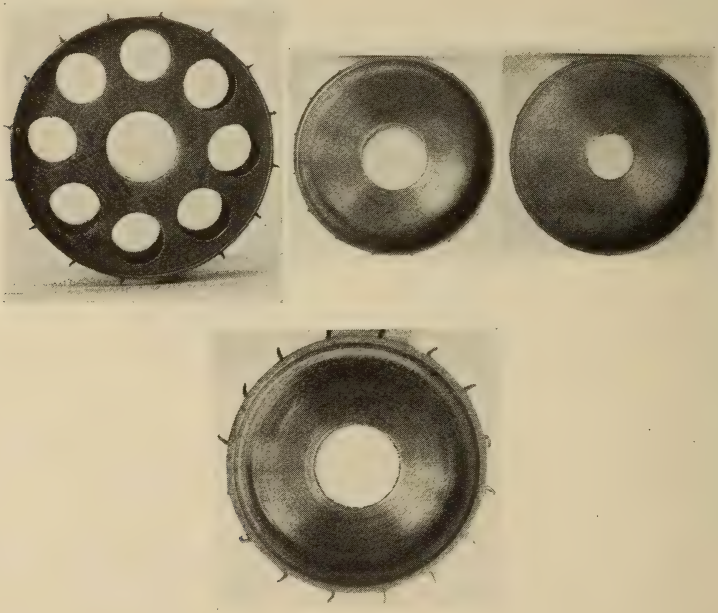


Fig. 3.

I have already shown you a badly worn sprocket. I now present to your attention some which are in even worse condition, again assuring you that these sprockets were reduced to this state by actual wear in projecting pictures in a theatre. I invite you to mentally estimate the amount of damage which would be done to prints passing over either of the two upper examples, remembering

that the projectionist would, in self-defense, jam the gate tension down as tight as he could get it, because that would operate to reduce the jump of the picture on his screen, though it would tend to vastly increase the jump in theatres using the films thereafter.

As to the two lower ones, I leave it to you to decide how it was possible to get them to pull film down against the braking friction of the gate tension shoes.

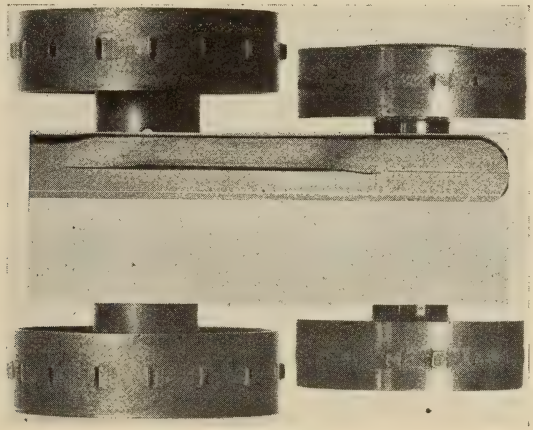


Fig. 4.

Our next illustration is a composite photograph of two intermittent sprockets and two views of an aperture plate track. Observe the deep groove worn in the latter. At the left is an edge view showing that the film has by friction almost worn entirely through the metal, the thickness of which may be observed by looking closely. It is seen that the film, in passing over such a track would pass the aperture in the form of a rather flat bow, hence it could not possibly be focused in the form of a rather flat bow, hence it could not possibly be focused at all points on the screen. Yet this exhibitor apparently preferred that the picture be out of focus on portions of his screen, and probably out of focus pretty badly too, to the expenditure of the small sum of money necessary to install new tracks.

I offer this as indisputable proof that there still are exhibitors in the business who have absolutely no conception of the damage done to their business in loss of revenue by such procedure—I had almost said this insane procedure. I offer these evidences of rank abuses as evidence that there still is need for education of exhibitors

in the matter of projection equipment maintenance. I could offer thousands of them if given time to make the collection. There are, I think, representatives of projector manufacturers here present who can vouch for the fact that enormous damage is done to the industry by failure of exhibitors to keep projection equipment in a good state of repair, and by continuing to use equipment, particularly projectors, for years after they are out of date and ought to be superseded by later, improved apparatus.

But, some of you may ask, what can the Society of Motion Picture Engineers do about this matter? Assuming all that you say to be true, how may we act to remedy it?

Gentlemen, while it is very true that our Society cannot remedy the condition, still it is also true that it can aid in its amelioration in several ways. The Society can, first of all, voice vigorous condemnation of the practice here complained of. It can, and it should direct the attention of the entire industry to the damage done to it, and to every part of it by improper display of its finished product to the buying public in any but the best possible manner—the manner which will cause it to have its highest possible value in amusement and entertainment.

Thanks to our good friend and member, Mr. P. A. McGuire, there now is in existence an organization by means of which matters vital to the proper display of motion pictures before theatre audiences may be widely distributed to projectionists and to theatre managers. I am sure that the paper of which I am editor and the department I edit in a trade paper of very wide circulation, will be only too glad to assist the Society by giving full publicity to any action it may see fit to take looking to proper maintenance of projection equipment.

But before any agency may move in support of any action, this body must make the first move, I therefore suggest that this Society voice its hearty approval of proper maintenance of projection equipment; that it officially, in a statement prepared by our Secretary and approved by our Board of Governors, direct attention to the fact that in order to effect a display upon theatre screens which will give photoplays their fullest possible value in entertainment and amusement, it is imperatively necessary that the projection equipment, and especially the projectors themselves be at least reasonably up-to-date and in a perfect state of repair.

This Society now has high standing in the industry. Such a statement officially issued by it could not fail to have a salutory effect, and there seems no good reason why it should not be issued.

We all know that projection equipment is not kept in perfect condition, though possibly some do not know to what a terrible state of disrepair much of it is permitted to fall. Surely we all must know that disrepair in the vital parts of the projectors themselves cannot possibly fail to result in damage to the screen image.

If any official action be taken by this body such as I have suggested, or any action of any sort tending to secure the results sought, I think I may promise that it will have the widest possible publicity. And surely, gentlemen, there can be no possible legitimate objection to such an action.

FIG. 5

In conclusion I would direct the attention of this body to the fact that one of the reasons for the existence of our Society is the elimination of abuses and wrong practices which work to the injury of the product this industry has to sell to the public.

This being true and I think we must all agree that it is true, surely it is right and proper that we take any action compatible with the dignity of the Society which gives promise of assisting in the abatement of the known evils.

DISCUSSION

MR. EDWARDS: This is not a criticism of Mr. Richardson's paper but merely a few words in amplification of it.

I happen to be Chairman of the Claims Department for one Projectionists Local. It is my job to settle disputes between the Local and the Managers on claims for damages. There are in many theatres, sprockets almost as bad as those you have seen on the screen here today. I have on many occasions called the manager into the projection room, pointing out parts that needed repair badly and have been told "Why should I worry; people don't know any better."

There is a crying need for the work of this Society to be broadcast among the exhibitors. It is no use saying they are in a different

class, and we do not have to bother with them. They are cogs in the machine and if those cogs are inefficient the work of the entire machine will be hampered.

I have no suggestion to offer as to how that may best be done, but it should be taken up. The ignorance of the average manager with regard to projection is simply amazing. That tension shoe you were shown—there was one I managed to get replaced that was a much worse specimen than the one you were shown. There were three distinct waves cut into it and each wave was nearly a thirty-second of an inch deep. Something must be done to wake these people up and make them realize the importance of seeing to projection equipment repairs. What sort of work would a druggist do if he were supplied with a pair of scales, for instance, that were only correct within two or three drams?

I think a committee might be formed within the Society to undertake work of a circularizing nature amongst the exhibitors, pointing out just what the Society is doing and some of the things that are hurting the business.

The exhibitor usually gives as his excuse for not making repairs "business is bad"; and the request of the man who runs the projector for new parts is met with "I'll see about it".

MR. TOWNSEND: Within the past five or six years I have been approached by theater managers in my own town—by at least three of them—to buy our cast-off intermittent sprockets. I can truthfully say that two of those managers are now looking for a job. They didn't get the sprockets from me. Imagine a man who is considered to be a theatre manager trying to buy sprockets which have been discarded by another theater!

MR. ROSS: We have the following suggestion to make: We assume the exchanges have an association and suggest that it appoint an inspector and that the exhibitors' projectors be inspected and O.K.'d before film is delivered to him; in other words, if the projector doesn't pass inspection ,the exhibitor gets no film.

MR. RICHARDSON: I have had that matter up with exchanges for five years. The trouble is it costs something. Perhaps the Society could start some such action. I have spent a great deal of effort and postage urging it. I think I did get it started but it died because it cost something.

TINTED FILMS FOR SOUND POSITIVES

Loyd A. Jones*

POSITIVE motion picture film on tinted support has been available for many years. It has been used extensively; in fact during some periods within the past few years eighty to ninety per cent of the total production has been printed on tinted positive film. There is little doubt that the employment of material which imparts a pleasing and variable color to the screen adds to the beauty of the production, breaks the monotony of looking for long periods at a plain black and white picture, and softens harsh outlines which otherwise may produce unpleasant impressions. But of much greater importance than these rather incidental æsthetic contributions of color is its great potential power to enhance, by either objective or subjective association, the emotional significance of the scene with which it is associated. It must be admitted that the language of color—the more or less precise evaluation of the emotional value of the various hues, tints, and shades—is at present in a very rudimentary stage of evolution. Correlations are in many cases subconsciously *felt* without being consciously *defined*. It is entirely possible, and in fact probable, that careful study and experimentation may lead to the development of this language or symbolism into a powerful emotional tool in the hands of the master motion picture dramatist.

Recent scientific advances have made possible the reproduction of sound along with the motion picture, the sound record, consisting of a series of photographic images varying in either density or width, being carried on the edge of the positive film band. Although this has added enormous possibilities to the dramatic power of the motion picture, it has made it impossible to continue the use of the tinted positive films which have been employed during past years. The recorded sound is reproduced by the action of light which passes through the record on the positive film and excites a photo-electric cell. The majority of dyes used in making these tinted bases absorb strongly those wave-lengths of radiation to which the photo-electric cell is most sensitive. Hence the response of the cell is so reduced

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in magnitude that high amplification of the photo-electric currents is required to obtain sufficient volume of sound. This high amplification may increase unduly the inherent cell noises and microphonic disturbances in the amplifier so that the reproduced sound is of intolerably poor quality. As a result, the use of tinted film has been entirely discontinued in the production of positives carrying a photographic sound record. There is little doubt that this absence of color from the screen constitutes a serious impairment of the beauty and dramatic power of the screen production. It is desirable, therefore, that a means be found for producing a tinted positive film which, when used in making sound positives, will not interfere with the satisfactory reproduction of the sound record carried thereon.

All-over Tints vs. Clear Sound Track

This problem can be solved provided coloring materials can be found which, while absorbing a relatively small amount of that radiation to which the photo-electric cell is most sensitive, will produce, by selectively absorbing the radiation to which the eye is sensitive, colors or tints of the desired hue and brilliance. These dyes, or carefully determined combinations of dyes, can be applied to the film base in the usual manner and thus enable the manufacturer to offer a product at no greater cost than the regular clear base positive film.

Another solution of the problem lies in applying the tinting dyes to the film band in such a manner as to leave untinted a narrow strip of proper dimensions and position on the film band. The sound record can then be printed on this uncolored area and the sound will be satisfactorily reproduced without interference of the tinting material. Unfortunately this method involves a greater cost of manufacture, since the tinting dyes must be applied to the individual 35 mm. strip after the base has been emulsion coated and cut into narrow widths. It is obvious that technically this represents the most satisfactory solution. This was recognized by us some considerable time ago and applications were made for patents to cover the idea. Methods and machines for accomplishing this have been devised which give very satisfactory results and it is probable that this material will be available in the near future.

The first solution suggested, namely, the use of dyes or other coloring materials applied over the entire area of the film and so

adjusted spectrophotometrically as to transmit freely the radiation to which the photo-electric cell is sensitive, seemed worth further study, and after a rather lengthy series of experiments a number of satisfactory tints have been obtained. These represent the entire gamut of hue and, in our opinion, are of the most satisfactory depth or color saturation for use in applying color to the motion picture screen.

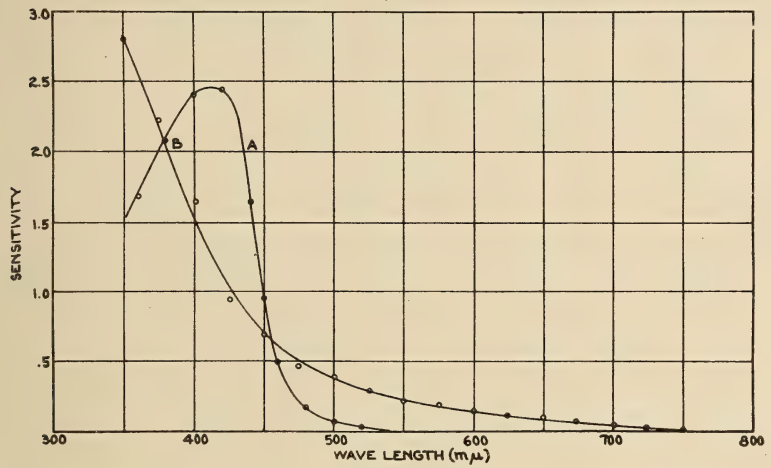

FIGURE 1. Spectral sensitivity curves for (*A*) potassium gas-filled photo-electric cell, (*B*) caesium photo-electric cell.

Color Sensitivity of Different Photo-electric Cells

In approaching the problem of selecting dyes for this purpose it is necessary, first of all, to determine just what wave-lengths of radiation most strongly excite the photo-electric cell with which the tinted material is to be used. It is necessary, therefore, to determine the spectral sensitivity of such cells. Photo-electric cells may be made by using any one of several different materials, such as potassium caesium, sodium, and other alkali metals. These may be of either the evacuated or the gas-filled type. The spectral sensitivity depends upon many factors and as a result cells differing enormously in spectral sensitivity are available. To the best of our knowledge, however, there are only two types of cells used extensively in commercial installations for the photographic reproduction of sound. One of these, manufactured by the Western Electric

Company and used in the equipment installed by the Electrical Research Products Incorporated, is of the potassium gas-filled type. The other, used in the equipment installed by the Radio Corporation of America, is of the caesium type.

In Fig. 1 are shown the spectral sensitivity curves of these two cells, curve A being that for a potassium and curve B that for a caesium cell. The ordinates of these curves are proportional to the photo-electric currents generated when excited by equal amounts of energy of the wave-length as indicated by the abscissa values. The proportionality constant used in blotting these curves is not the same for the two cells; hence these curves cannot be interpreted as

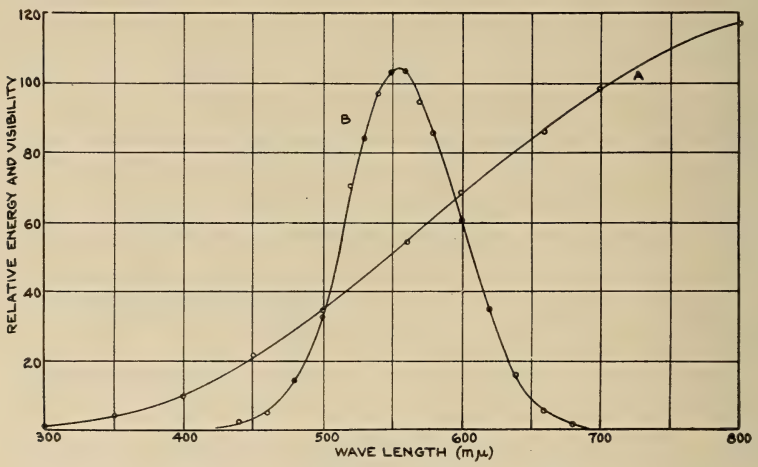

FIGURE 2. Visibility and tungsten energy (3000°K): (A) relative energy of radiation from tungsten at 3000°K; (B) visibility of radiation (relative brightness for equal energies).

indicative of the relative total sensitivities of the two cells. They do show, however, the way in which sensitivity varies with wave-length, and this is the information in which we are particularly interested at present. The monochromatic radiation used in the determination of these sensitivity functions was of high spectral purity, being obtained by using two monochromatic illuminators operated in tandem so as to effectively eliminate all scattered radiation. The photo-electric current generated was measured with a high-sensitivity galvanometer. The amount of energy incident upon the photo-electric cell was measured by means of the thermopile

and high-sensitivity galvanometer. Since the thermo-electric current is directly proportional to the energy incident upon the thermopile (regardless of wave-length) it follows that the sensitivity of the photo-electric cell, defined in terms of the photo-electric current per unit of energy, is directly proportional to the ratio of the photo-electric current to the thermo-electric current, P_c/T_c. Every precaution was taken to eliminate all possible errors and it is felt that the curves shown in Fig. 1 represent with high precision the sensitivity of the cells in question. The author is indebted to Dr. Otto Sandvik of these laboratories for these data.

The curves in Fig. 1 show the relative magnitude of the photo-electric currents resulting from the action of equal amounts of energy of different wave-lengths. In practice, the photo-electric cell is excited by an incandescent tungsten lamp which does not emit equal amounts of energy at all wave-length. To obtain the effective spectral response curve it is necessary to know the spectral distribution of energy in the radiation emitted by the incandescent tungsten lamp. This depends upon the temperature at which the filament is operated. In commercial sound reproducing installations this is approximately 3000°K. In Fig. 2, curve A shows the relative intensity of the radiation emitted at different wave-lengths for this source. It will be noted that relatively little energy is emitted in the short wave-length region to which the photo-electric cells are most sensitive, while relatively large amounts of radiation are emitted at longer wave-lengths.

In Fig. 3 are shown the effective spectral response curves for each of the two cells when used with a tungsten lamp operating at 3000°K. The ordinates of these curves are determined by multiplying, at each wave-length, the ordinate of the sensitivity curve (see Fig. 1) by that of the tungsten energy curve, Fig. 2.

It will be noted that the response curve of the potassium cell (A, Fig. 3) has a relatively high sharp maximum at wave-length 425 mμ. It decreases rapidly for both longer and shorter wave-lengths, reaching a value of 10 per cent of the maximum at 490 mμ, on the one hand and 340 mμ (estimated) on the other. The effective response curve for the caesium cell is shown in Fig. 3, curve B, and is of a broad flat type having a maximum at 420 mμ. For longer wave-lengths the response decreases gradually reaching a value which is 10 per cent of the maximum at approximately 750 mμ.

The response at 700 mμ, the long wave-length limit of the visible spectrum, is 35 per cent of that at the maximum. It will be noted that the maximum of response is at practically the same wave-length for these two cells, although the caesium cell has a much broader spectral sensitivity than the potassium cell. It is evident from a consideration of these response curves that any coloring material which absorbs strongly in the region between 400 and 500 mμ

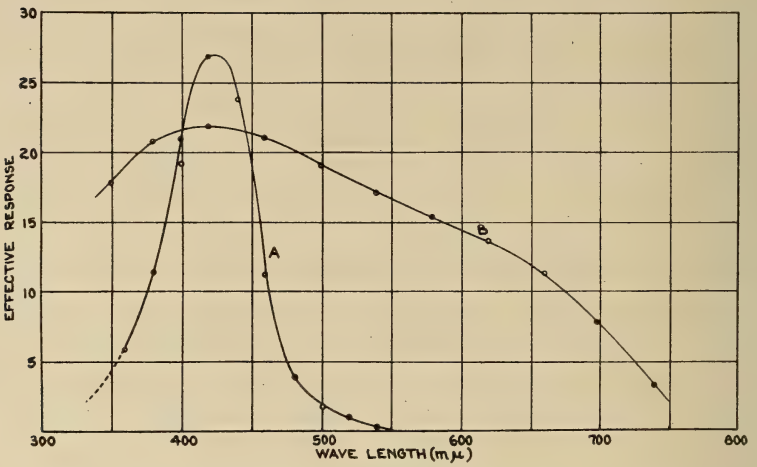

FIGURE 3. Effective spectral response curves when using a tungsten lamp operating at 3000°K: (A) potassium cell; (B) caesium cell.

will have a relatively high density if measured in terms of this photo-electric cell and a tungsten lamp. These wave-lengths impinging on the retina give rise to the colors described qualitatively as violets and blues, and if these wave-lengths are absorbed from white light the remainder produces a yellow color. Yellow dyes in general therefore have high photo-electric densities. This is true qualitatively for both cells although it applies with much greater force in case of the potassium cell which has a relatively narrow sensitivity band in the short-wave region. As a result of the difference in shape of the response curves, certain colors, such as yellows, give relatively lower photo-electric densities when measured with the caesium cell than when this quantity is determined by means of the potassium cell.

Color Sensitivity of the Eye

The eye is a receptor of the synthetic type and does not analyze a heterogeneous radiation into its component parts. The sensation arising from the impingement of heterogeneous radiation on the retina has a single hue characteristic, and identical sensations of hue may be excited by heterogeneous radiations differing very widely in actual spectral compositions as determined spectrophotometrically. It is evident, therefore, that there is a possibility of obtaining a desired color by several different types of spectral absorption curves. Since the radiation required to actuate the photo-electric cell is localized in a very definite wave-length region, it follows that the course to be pursued in the solution of the problem in hand is to select absorbing materials which most efficiently transmit these wave-lengths and at the same time most completely absorb those wave-lengths which, when subtracted from white light, operate most efficiently toward the production of a color having the desired hue and saturation characteristics.

In order to proceed most directly and logically in this direction, knowledge of the visibility of radiation is of considerable importance. This knowledge is of assistance in deciding just what particular type of selective absorption will most efficiently produce a desired color and, at the same time, most efficiently transmit those wave-lengths which are required to excite a photo-electric cell. Curve B in Fig. 2 shows this visibility function, the ordinates being proportional to the magnitude of the visual sensation produced by the action on the retina of equal intensity of radiation of the various wave-lengths, as indicated by the abscissa values.

By judicious choice of dyes and dye mixtures which give spectral absorptions correctly adjusted with respect to the photo-electric response and to the retinal sensitivity, it has been found possible to produce a series of colors having hues distributed throughout the entire hue scale and at the same time having relatively low densities as measured with either the potassium or the caesium photo-electric cell-tungsten lamp (3000°K) combination.

As a preliminary to this work a careful spectro-photometric analysis showing the selective absorption characteristics of several hundred available dyes was made. It was soon found that it would be quite impossible to produce colors of the red-orange-yellow group without absorbing some of the radiation to which these photo-

electric cells are most sensitive. The question then arose as to the absorption permissible in practice. There are really two phases to this particular problem, one involving a determination or decision as to the magnitude of photo-electric absorption for which satisfactory compensation can be made by increasing amplification without encountering serious electrical difficulties or sacrifice of quality in the reproduced sound. The other involves a consideration of the volume change which takes place in passing from one color to another when these are assembled consecutively in a reel of sound positive.

Permissible Range of Photo-electric Density of Tints

A large number of experiments were made in this laboratory to gather information upon which a rational decision relative to these points could be made. After having reached conclusions as to satisfactory values for maximum and minimum photo-electric density values, the matter was discussed with several authorities in the field of photographic sound reproduction, communicating engineering, and acoustics. The opinions from these individuals corresponded surprisingly well with those based upon our experimental results. There seems to be no difficulty encountered in increasing amplification to compensate a photo-electric density of 0.3. This photo-electric density can be looked upon as equivalent to a certain loss of volume which in turn can be expressed in terms of transmission units (decibels). In order to convert a density value, density being defined as the logarithm of the reciprocal of transmission, to equivalent decibels it is only necessary to multiply by 20. Thus if an optical density of 0.3 (measured, of course, in terms of the photo-electric cell and tungsten lamp combination being used) be inserted between the exciting lamp and the photo-electric cell it will be necessary to increase the amplification by 6 decibels in order to obtain the same volume output. On commercial equipment the volume control is adjustable by steps, in some cases each step corresponding to 2 decibels, and in others to 3 decibels. Thus, the use of a tinted film base having a density of 0.3 will necessitate advancing the volume control by either 2 or 3 steps. This represents a relatively small percentage of the total amplification, and there seems to be little doubt that the required increase in amplification can be obtained satisfactorily.

Permissible Volume Changes

The permissible change in volume occurring in passing from one tint to another is, in the last analysis, dependent upon the sensitivity of the ear to changes in volume. Under ideal conditions of observation, the change in loudness corresponding to a volume change produced by one decibel variation in amplification is just perceptible. It should be remembered that this change is perceptible only under ideal conditions. The situation is similar to that which exists relative to photometric sensitivity, that is, the sensitivity of the eye to differences in brightness. For instance, in a photometric field where the two halves are immediately juxtaposed in such a manner that when the two parts of a field are identical in brightness the division line is invisible, a difference in brightness of 2 per cent (actually 1.7 per cent) is just perceptible provided that the field subtends a visual angle of 3°, that the brightness level is optical, and that all disturbing factors are removed. Such ideal conditions seldom exist in practical work, however, and it is customary to regard a brightness difference of 5 per cent as the least difference which is of importance. Similarly, in the case of oral sensitivity, when the comparison is made between pure tones of the same frequency immediately juxtaposed in time and of a loudness to which the ear is most sensitive, one decibel is just perceptible. In practice, however, it is probable that 2, or even 3 decibels constitutes a more rational specification of the amplification change which will produce a just noticeable difference in volume. On assuming, therefore, that a section of uncolored base is followed by a colored base having a photo-electric density of 0.3, the change in volume of 6 decibels will represent two, or perhaps three, just noticeable differences. Although this variation in most cases may not be unduly objectionable, it is felt that it is somewhat too great to meet the most rigid requirements. It is therefore proposed to establish also a lower density limit of 0.10 and to adjust the selective absorption of all the members of the series so that none shall have a density less than this value. Furthermore, it is proposed that when a hueless screen is desired a positive film tinted with a neutral (non-selective) dye be used. The photo-electric and, incidentally, the visual density of this is adjusted to a value of 0.10 corresponding to 2.0 decibels. If this material is used in conjunction with one having a density of 0.3 the volume change occurring at the transition from one to the other

will be that corresponding to a change in amplification of 4.0 decibels. This total change is a little greater than the volume change which under practical conditions is just noticeable, and is certainly less than two such steps. It is felt that volume changes of this magnitude are entirely negligible in practical work, especially since a change from one tint to another usually occurs with a scene change at which point a slight volume change may logically be expected.

It is of interest to apply this reasoning also to the case of maximum permissible density discussed in the previous paragraph. It will be recalled that a value of 0.3 for photo-electric density was fixed as being a reasonable upper limit. The amplification change required to give the same volume with such a film, as compared with clear base positive, is 6 decibels, which corresponds to two or perhaps three just noticeable volume differences. It is evident that this represents a relatively small increase in amplification and that no serious difficulty should be encountered in raising amplification sufficiently to compensate for the use of a colored base having a photo-electric density of 0.3.

The conditions which have been established, relative to permissible photo-electric density of tinted base for use in making sound positives, may be summarized as follows:

Maximum photo-electric density 0.3, amplification increment 6 decibels.

Minimum photo-electric density 0.10, amplification increment 2 decibels.

Maximum variation in density 0.20, maximum volume variation 4 decibels.

It should be understood that the values of density specified above are relative to clear film base taken as equivalent to a transmission of 100 per cent, density 0. It seemed desirable to express all results in this manner since the factors of interest are those relating to the changes of photo-electric transmission, volume, etc., as compared to the conditions existing when the sound record is carried on a clear film base.

Visual Characteristics of the Seventeen Tints

In Table 1 are given data relative to the visual characteristics of these tinted materials. Considerable thought has been given to the names by which these tints are to be designated. It seems

desirable, from a consideration of the probable associational and emotional value of color when applied to the motion picture screen, to designate these tints by names suggestive of their potential psychological effects and appropriate uses. This particular phase of the subject will be discussed in greater detail in a later section of the paper. In the column designated as "λ" under the title "Hue" are given the values of the dominant hue expressed in wavelength. These determinations refer specifically to the color of a white screen when illuminated by light from an arc of the reflector type with the tinted base placed between the light source and the screen. It therefore is a specific designation of the screen color obtained when these materials are used with a light source of this character. It is realized that in practice a certain variation in these hue values will result from the use of light sources differing from the one with which these hue measurements were made. For instance, with a high intensity arc of either the condenser or the reflector type, the color of the emitted light is probably slightly bluer than that emitted by a reflector arc using ordinary hard-cored carbons. Under these conditions the hue values will be shifted slightly. The difference, however, is so little as to be considered negligible

TABLE I

Visual characteristics of the series of tints

No.	*Color Name*	*Hue*		*T*	*Description*
		λ	*No.*	%	
0	Clear base	——	——	100	Hueless, clear
1	Rose Dorée	633	1.0	57	Deep warm pink
2	Peachblow	619	4.0	61	Flesh pink
3	Afterglow	603	7.5	66	Orange
4	Firelight	596	12.0	66	Yellow-orange
5	Candleflame	585	17.5	75	Orange-yellow
6	Sunshine	579	23.0	83	Yellow
7	Verdante	520	36.0	57	Green
8	Aquagreen	505	40.0	40	Blue-green
9	Turquoise	490	43.0	46	Blue
10	Azure	484	47.0	28	Sky-blue
11	Nocturne	476	51.0	28	Violet-blue
12	Purplehaze	455	56.5	38	Blue-violet
13	Fleur de lis	—575	60.0	25	Blue-purple
14	Amaranth	—557	64.0	31	Red-purple
15	Caprice	—537	67.5	53	Cool pink
16	Inferno	—508	71.5	36	Red-magenta
17	Argent	——	——	71	Hueless

from the practical standpoint. If these materials are used in a projector employing a high efficiency tungsten lamp there will prob-

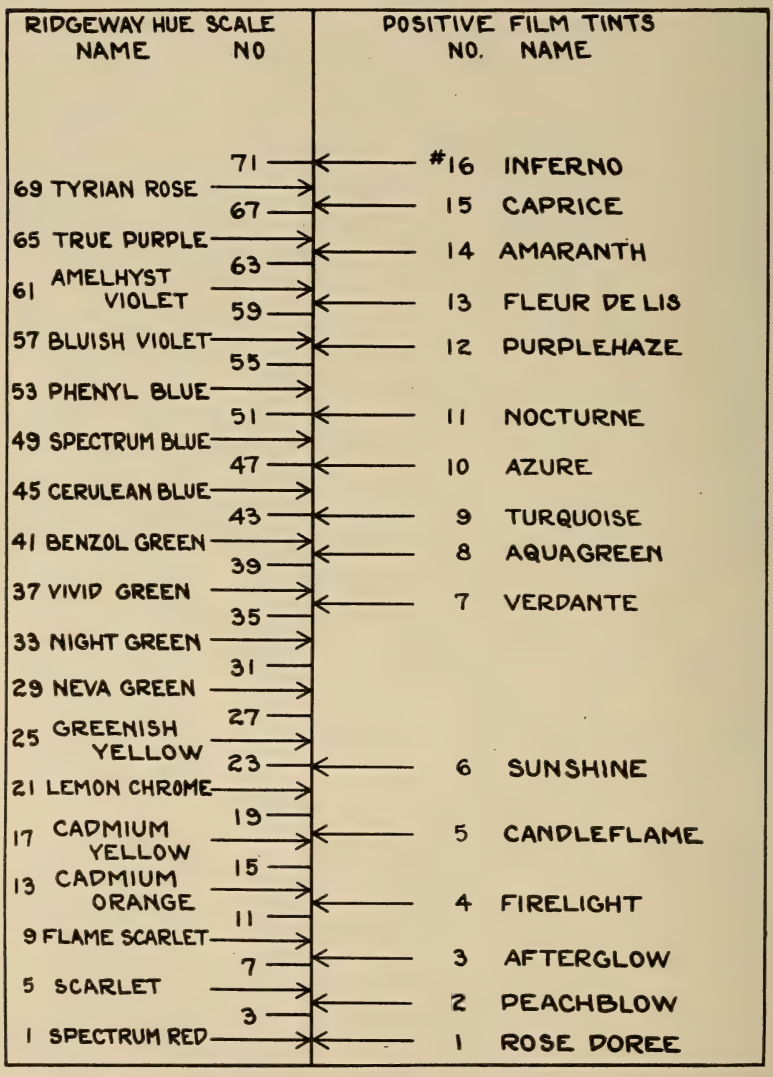

FIGURE 4. Positions of the tints on the Ridgway Hue Scale.

ably be a rather great departure from the hue values indicated in Table 1. This light is much yellower than that emitted by the arc

and hence the use of a screen illuminated by a tungsten lamp in conjunction with these tinted bases will give appreciably different hues from those indicated in Table I. In the column designated as "No." under "Hue" are the Ridgway hue numbers. The system of color nomenclature developed by Ridgway[1] is one of the best available. The entire hue gamut, including the spectral hues and the non-spectral purples, is divided into 72 hue steps. These hue steps are equally placed on the sensation scale.

Tints Evenly Spaced Along Normal Hue Scale

In setting up a scale of hue it is not satisfactory to adopt intervals which are identical in wave-length difference because the sensitivity of the eye to hue differences varies enormously throughout the spectrum. In order to establish a normal hue scale in which the steps are equal in terms of sensation, it is necessary, therefore, to use wave-length intervals differing widely in magnitude. It will be noted that, with the exception of a region in the orange, yellow, and yellow-green, the hues of these tinted materials are fairly evenly spaced on the normal hue scale. It seems highly desirable to adopt such spacing, since it makes available the entire gamut of hue and a change from one tint to another produces a hue displacement of known and fairly equivalent subjective magnitude. The positions of the dominant hues of these colors are shown graphically on the chart in Fig. 4. At the left are given the Ridgway hue numbers and the names applied by Ridgway to these hues when occurring in colors of high saturation. At the right in the first column are the numbers for the tinted positive films, and the names applied to these. It should be remembered that these colors are in general of relatively low saturation and it is considered that these more delicate tints are of greater utility for use in applying color to the motion picture screen than those of higher saturation. It is a rather peculiar coincidence that the colors corresponding to the hue numbers 25 to 35, which are absent from this positive film series, are those which, according to all of the available psychological data (see Lukiesh, *loc. cit.*), are the colors *classified* as least agreeable or least preferred. These color preference data are derived from a large group of observers and hence are very significant. It has been impossible thus far to obtain these hues with sufficiently low photo-electric density.

Possibly further search may reveal dyes which will permit the manufacture of these hues if such seems to be necessary or desirable.

In Table 1, in the column designated as "T," are the values of total transmission for these colored materials as measured visually using the reflector arc as a light source. These values are therefore

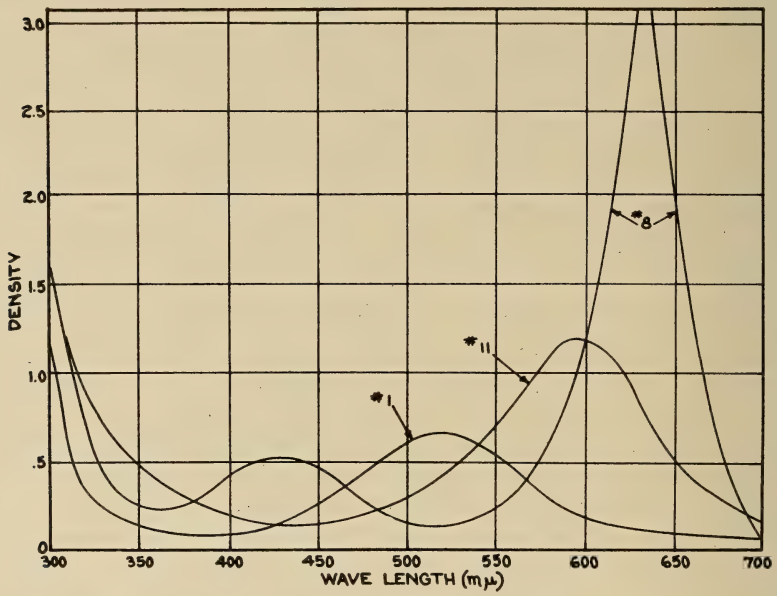

FIGURE 5. Spectrophotometric curves for Rose Dorée, Aquagreen, and Nocturne.

a direct measure of the screen brightness obtained when using these tinted materials as compared with the screen brightness existing when using clear base positive. It will be noted that the visual transmissions of the red, orange, yellow, and yellow-green colors are relatively high, while those of the green, blue, violet series are relatively low. This condition exists since it is desired to obtain fairly definite color saturation effects. It follows as a natural consequence of the visual sensitivity and transmission characteristics of dyes that the colors in the former group have relatively high visual transmissions for a specified color saturation, while the transmission values in the second group are in general low when a corresponding color saturation is obtained. In the last column are given short verbal descriptions of the color characteristics.

To show spectro-photometric curves for all of the seventeen members of this series seems unnecessary, but it may be of interest to consider two or three typical cases. In Fig. 5 are given such curves for tint No. 1 (Rose Dorée), a warm deep pink; tint No. 8 (Aquagreen), a clear blue-green; and tint No. 11 (Nocturne), a deep violet-blue. Inspection of the curves shows that each of these colors has a decided density minimum throughout all or some part of that wave-length region in which the photo-electric response is maximum. The minimum density does not fall at the same wave-length in each case but shifts with the demands of the selective absorption necessary for obtaining the desired visual hue.

TABLE II

Photoelectric density characteristics of the series of tints

	Film Tint	*Potassium Cell*		*Caesium Cell*	
		D	*T.U.*	*D.*	*T.U.*
0	Clear base	0.0	0.0	0.0	0.0
1	Rose Dorée	0.19	3.8	0.15	3.0
2	Peachblow	0.17	3.4	0.11	2.2
3	Afterglow	0.27	5.4	0.15	3.0
4	Firelight	0.27	5.4	0.11	2.2
5	Candleflame	0.24	4.8	0.09	1.8
6	Sunshine	0.27	5.4	0.06	1.2
7	Verdante	0.28	5.6	0.18	3.6
8	Aquagreen	0.26	5.2	0.27	5.4
9	Turquoise	0.10	2.0	0.24	4.8
10	Azure	0.09	1.8	0.27	5.4
11	Nocturne	0.09	1.8	0.28	5.6
12	Purplehaze	0.10	2.0	0.22	4.4
13	Fleur de lis	0.14	2.8	0.30	6.0
14	Amaranth	0.11	2.2	0.24	4.8
15	Caprice	0.09	1.8	0.14	2.8
16	Inferno	0.18	3.6	0.22	4.4
17	Argent	0.09	1.8	0.10	2.0
	Mean	0.176	3.5	0.184	3.7
	Maximum	0.28	5.6	0.30	6.0
	Minimum	0.09	1.8	0.06	1.2
	Maximum Δ	0.19	3.8	0.24	4.8

In Table II are given data relating to the photo-electric density characteristics of these materials for potassium and caesium cells of the types in extensive use in commercial installations. Density values are designated as "D," while in the columns designated as

"TU" are given the equivalent values in decibels, these representing the amplification increment required to compensate for the volume depression occasioned by the use of these materials.

It will be noted that the specifications relative to maximum density and maximum density difference previously set forth as desirable have been met in actual materials with a fair degree of precision. In case of the potassium cell the maximum density is

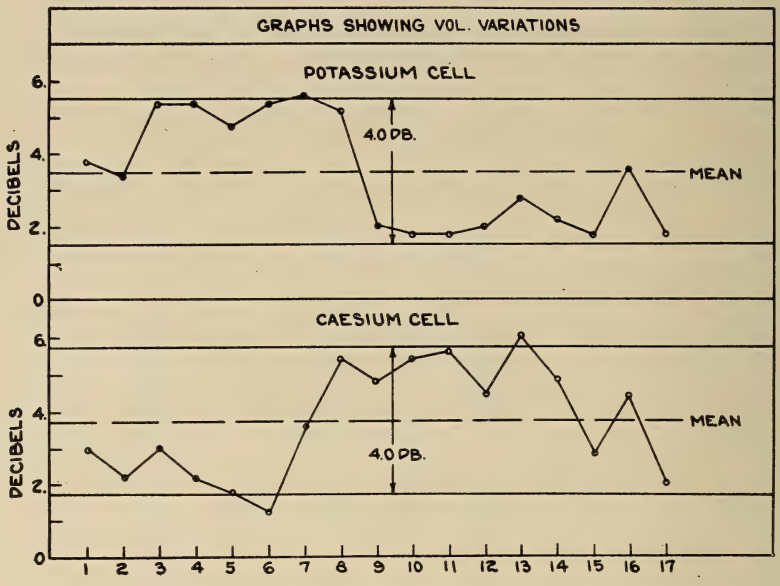

FIGURE 6. Volume variation resulting from the use of the series of seventeen tints.

0.28 (No. 7, Verdante), slightly less than the value of 0.30 considered allowable, while the density difference between the upper and lower limits is 0.19 (equivalent to 3.8 decibels), also slightly less than that considered tolerable. With the caesium cell the maximum density is exactly 0.30 (No. 13, Fleur de lis), while the maximum difference is 0.24, not appreciably greater than the specified 0.20.

The volume variation through the entire series of seventeen tints is shown in Fig. 6. The ordinates indicate the increase in amplification, expressed in decibels, required in each case to give the same volume output, with the tint as indicated by the numbers at the bottom of the figure, as compared with a sound record of

identical characteristics on the regular clear positive film. The horizontal lines are drawn at plus and minus 2 decibels from the mean of the entire group. These lines therefore define the allowable volume change as previously specified. In case of the potassium cell all of the tints fall between these limits; with the caesium cell two of the tints fall slightly outside these limits.

Prints have been made on all of these colored bases and sound reproduction with each cell is considered satisfactory, both with respect to the increase in amplification required and the maximum volume variation. It is hoped that the sound prints to be shown a little later will demonstrate this point to your satisfaction.

This concludes that part of the paper which may be designated as technical, dealing, as it does, with the objective or physical characteristics of tinted positive film base. The application of these colors to a motion picture production involves the consideration of a radically different group of relationships belonging to that phase of the motion picture industry which has been designated, for want of better term, as artistry.[2] While it may be presumptuous on the part of the author of this paper to invade a field so remote from that of his accustomed activities, he feels that there may be some members of the Society more concerned with the artistic and emotional reactions than with the cold facts of scientific technology, who may be interested (or perhaps amused) by some thoughts and suggestions as to the possible emotional and artistic value of color applied to the motion picture screen. Some of you may have been present on one or two previous occasions when the author has had the privilege of presenting to this Society papers, written in collaboration with Townsend[3] and Tuttle,[4] discussing the use of color in more or less abstract static and dynamic forms as a valuable element in a motion picture program. You are already aware, therefore, that he has long been interested in the possibilities of color as an aid to the creation of dramatic atmosphere. In fact he is firmly convinced that color *per se,* if properly employed, may exert a powerful influence on the emotional reactions. He therefore begs your indulgence while in the following pages a few ideas along these lines are presented for your consideration.

The Language of Color

The literature pertaining to the language, symbolism, and emotional effects of color, though scattered and fragmentary, extends

over the entire period of recorded history. Mythology is replete with the symbolism of color. On the Greek stage the colors of the costumes were adjusted to the mood of the action. Color is intimately associated with the entire history of the Christian Church and a very definite color symbolism has developed. Color has been so inseparably linked with sensory experience throughout the evolution of mankind that it has acquired by objective and subjective association definite and important emotional value.

No attempt can be made within the confines of this paper to give anything approaching a complete bibliography of the subject. One or two references, however, may be valuable to those interested. Field in his *Chromatography*[5] discusses various colors from the standpoint of their emotional value and gives numerous references tending to show rather general agreement as to the character of such effects. A quotation given by Field[6] from Opie,[7] an English artist of the late 18th century, is of particular interest.

"Every passion and effection of the mind has its appropriate tint and coloring, which if properly adapted, lends its aid, with powerful effect, in the just discrimination and forcible expression of them; it heightens joy, warms love, inflames anger, deepens sadness, and adds coldness to the cheek of death itself."

The most recent, complete, and by far the best publication on this subject is that by Luckiesh.[8] This is a carefully considered conservative treatment in which are given numerous data collected from many fields along with the valuable contributions of the author to this subject. The book will repay careful study and is earnestly recommended to the attention of those interested. The following quotation[9] is of interest as it indicates the attitude of the author toward the subject and is an admirable statement of the point of view which should be taken by any investigator in a little known field.

"It would be unscientific to deny the existence of a language of color because we do not understand it thoroughly at present and quite unprogressive to reject the possibility of finally completing the dictionary of this language. Color experiences are indeed very intricate at present but it is likely that this is due to our scanty knowledge of the elements and processes involved in the emotional appeal of colors, and to our inability to interpret and to correlate properly the various factors. Much knowledge must be unearthed before a rudimentary dictionary of this language is available but

first the scientific attitude should admit the possibility that the language of the group of experiences associated with color eventually will be understood."

In considering color from this point of view it must be remembered that we are now dealing with color as it appears, that is, the sensation evoked in consciousness, rather than with the objective character of color as determined by its physical characteristics. All of the various factors, therefore, which determine the character of the subjective reactions, such as simultaneous contrast, previous retinal excitation, and many others must be considered in attempting to define the emotional reaction that may be induced by subjecting the eye to stimulation by radiation of known physical composition. Moreover, a color may, just as a word or phrase, have more than one emotional value or significance; and, as in the case of the spoken language, the intended meaning must be determined by the contextual factors such as general character of the scene structure, subject matter of preceding sequences, type of dramatic action, etc. For instance, a green matching in hue and saturation characteristics the color of spring foliage, may connote by direct subjective association, springtime, trees, grass, gardens, etc. Used on radically different types of scenes, however, such as interiors, it may be found particularly valuable for suggesting by indirect or subjective association certain more abstract concepts, such as youth, freshness, hope, aspiration, and those moods closely linked in our consciousness with the springtime of life.

Objective and Subjective Color Associations

A rather careful analysis of the admittedly rudimentary color language indicates that the great majority of existing connotations may be classified in two rather distinct groups which may be designated as *(a)* direct objective association and *(b)* indirect subjective association. It is relatively easy to quote many examples of the class *a* correlations. For instance, sunlight is quite definitely suggested by yellow. Now, as a matter of fact, sunlight is not yellow, and it has been shown definitely that when the retina is excited by sunlight or by radiation of identical spectral composition in a visual field from which all possible contrasting areas have been removed, the sensation evoked is hueless, that is, corresponding to gray or white. A white object, however, illuminated by sunlight under a

clear blue sky appears yellow. It seems quite evident, therefore, that through centuries of evolution a definite conscious or subconscious relationship between sunlight and yellow has been so established that under artifical conditions yellow almost invariably suggests sunlight. Thus a motion picture scene printed on yellow base, such as tint No. 6 (Sunshine), should definitely suggest sunlight illumination whether it be an exterior flooded with light from the sun or an interior into which light is streaming through open doors or windows.

In a similar manner there seems to be a very definite relationship between other colors and the well-known artificial sources of heat and light. Artificial illumination of interiors is definitely suggested by a color which is either more saturated or has a hue somewhat more orange than the yellow suggesting sunlight. Firelight may be suggested by a color even more reddish in character. Such examples of objective association can be multiplied almost indefinitely. Subjective associational relationships are somewhat more tenuous and difficult to establish with certainty. Some of these undoubtedly have been built up in consciousness by somewhat artificial association of certain colors with definite emotional states. Others of these correlations may probably be traced to extensions of more direct associational factors. For instance, there seems to be a character of warmth associated with all of the colors in the yellow, orange, red, magenta category, while the remainder give a definite impression of cold or coolness. This is very probably an extension of the more direct associational value arising from the color of sunlight and fire and the atmospheric conditions normally associated with coldness. The association of color with certain temperamental phases of life, such as youth, maturity, old age, etc., can probably be traced to an extension of a more direct association with the seasons of the year. Space does not permit us to carry this analysis into greater detail, but a serious study of this subject can hardly fail to convince the fair-minded student that there is really some definite and psychologically sound relationships between colors and emotional states. Although a great deal of the work on this subject has been of purely qualitative, and perhaps temperamental type, there are available some rather definite and significant data. For instance, Luckiesh[10] *(loc. cit.* p. 200) gives some very interesting

TABLE III

Wells' data on the affective values of various colors

Total Number of Replies from 63 Subjects Indicating Three General Types of Mood-Reactions Due to the Twelve Different Colors

	Exciting Influence	*Tranquilizing Influence*	*Subduing Influence*
Crimson	41	0	10
Scarlet	56	0	0
Deep orange	59	0	0
Orange-yellow	55	6	0
Yellow	53	6	0
Yellow-green	14	39	5
Green	28	32	0
Blue-green	32	23	6
Blue	11	21	30
Violet-blue	0	17	45
Violet	0	6	54
Purple	3	1	48

data compiled by Wells[11] relative to the general types or mood reactions produced by twelve different colors. These data are shown in Table III. They are derived from sixty-three subjects and the correlation is indeed striking. There seems to be no escape from the conclusion that those colors designated as yellow, orange-yellow, deep orange, scarlet, and crimson have a definitely exciting influence. In the mid-spectrum yellow-green, green, and blue-green, seem to be definitely tranquilizing or soothing. Blue, violet-blue, violet, and purple are depressive or subduing. The student who approaches this subject with an open mind and with the intension of seriously searching for correlation factors can scarcely fail to be convinced that here is something of a very tangible nature which can be ascribed to a definite psychological reaction to color.

The chart in Fig. 7 shows the affective values of the various colors as computed from Wells' data. No definite information is available relative to the dominant wave-length of the colors used by him so they are plotted arbitrarily at equal intervals along the base line. The ordinates are computed from the data in Table III, each number being reduced to a percentage of the total number of decisions. The curves have the following significance: (A) curve of exciting influence; (B) curve of tranquilizing influence; (C) curve of subduing influence.

These curves are surprisingly similar in general shape and position to the three fundamental retinal excitation curves for red, green, and blue-violet. Although the present data are too meager to established any correlation between emotional effect and the retinal processes, the similarity is certainly sufficient to encourage some further consideration.

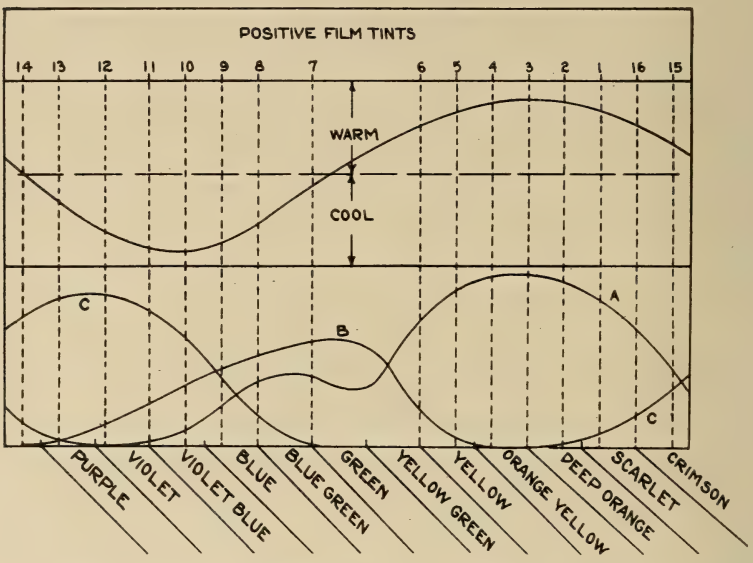

FIGURE 7. Affective values of the various colors computed from Table III: (A) curve of exciting influence; (B) curve of tranquilizing influence; (C) curve of subduing influence.

Along the top line of the chart are placed the numbers referring to the positive film tints, the position of each relative to the color scale at the bottom being determined as carefully as the qualitative data will allow. The dotted lines dropped from these points cut the three curves and the heights of these ordinates give some idea of the character and strength of the mood reaction which each color maye be expected to induce.

In the upper part of the chart is drawn a curve showing in a qualitative way the position on the warm-cool mood reaction scale. This, it must be confessed, is based on very insufficient evidence, being determined by the rather casual judgments by a few observers working under poorly controlled conditions.

Characterization of the Seventeen Tints

In the following paragraphs an attempt has been made to give a brief description of the visual and psychological characteristics of the film tints. It is evident that no very definite statements can be made or rigid specifications set up for the use of these colors. It is hoped that these rather disconnected and rambling remarks relative to the various colors may be of interest to those concerned with working out the application of color to the motion picture screen and serve as a foundation, however insecure, upon which something of real value may be built by others more qualified by training and temperament for such work. Although these characterizations of the symbolic and emotional values of these colors are necessarily tinged by the author's own reactions and by the results of his own introspective analysis, they are based, in so far as is possible, upon a careful summary and integration of data derived from the available literature. They should therefore represent approximately the reactions to be expected from the average observer.

Tint No. 17, Argent. This is a hueless color, a silvery gray showing no chromatic characteristics. It may be regarded as the zero or starting point on the scale of saturation or color strength. It is very necessary as a means of establishing a visual accommodation in terms of which a hue may be appreciated by contrast. It may be used to fatigue the eye to the point of monotony, after which the presentation of a hue will have enhanced effect.

Tint No. 6, Sunshine. A clear brilliant yellow approximately complementary to sky-blue, therefore quite closely matching the subjective color of sunlight when seen in contrast to blue sky. The visual transmission is high (83 per cent) ; therefore it is particularly adapted for use on a scene designed to give the impression of brilliant sunlit conditions and where an interior is obviously illuminated by sunlight entering through windows and open doors. This color is definitely warm but not to the same extent as Candleflame, Firelight, and Afterglow which make with this color a series increasing progressively in warmth. It is mildly stimulating, suggesting a mood of lively interest and attention, but not one of high excitement of nervous tension.

Tint No. 5, Candleflame. A pastel orange-yellow. It is slightly lower in transmission (75 per cent) than Sunshine, giving a screen more orange in hue and lower in brilliance which definitely suggests

artificial illumination when used on interior scenes. Somewhat warmer than No. 6. Possibly useful on exteriors in suggesting morning or afternoon with less intense sunlight than prevails at midday. By objective association useful in inducing rather mild mood reactions such as feelings of coziness, comfort, intimacy, well being, peace and plenty without opulence, etc.

Tint No. 4, Firelight. A soft yellow-orange. This is warmer than Candleflame to which it is closely akin in mood reaction value. The lower transmission (66 per cent) gives a somewhat less brilliant screen and this with the more orange hue makes it particularly adapted for use on an interior scene where it is desired to suggest an artificial illumination softened and subdued perhaps by shaded lamps and candles. It is suggestive also of illumination eminating from an open fire; but it is not quite orange or red enough to satisfactorily render the fire itself if visible, for which Afterglow is perhaps better. It stimulates mood reactions of the same category as Candleflame but with greater intensity. Suggestive of warmth, comfort, intimate home relationships, mild affection, etc.

Tint No. 3, Afterglow. A soft rich orange color. It is probably the warmest color of the series. It is appropriate to exterior scenes at dawn and sunset. It lends to interiors an atmosphere of warmth and intimacy stronger than Firelight. It should excite mood reactions in general connected with luxury, wealth, security, and relatively strong affections. It is also related to the autumnal mood by obvious direct association with the autumn colors of nature. By indirect or subjective association it is symbolic of the same relative period in the life of an individual and its associated moods. It is indicative, therefore, of repose, ambitions attained, accomplishment, and similar psychological aspects of maturity.

Tint No. 2, Peachblow. A delicate flesh pink. This has a small but definite blue content, making it somewhat less warm than Afterglow. It is adapted to the rendition of close-ups where it is desired to do full justice to feminine beauty. The hue and saturation are such as to suggest the glow of life.

Tint No. 1, Rose Dorée. A deep warm pink suggesting sensuousness and passion. Amorous, romantic, and exotic. It is adapted to the rendition of scenes representing an intimate atmosphere, such as a luxuriously appointed boudoir. In keeping also with feelings of happiness, joy, and excitement.

Tint No. 7, Verdante. A pure green, rather pastel in character. It is the hue of spring foliage, suggesting directly trees, grass, and vernal landscapes. By subjective association typical of youth, freshness, unsophistication, innocence, etc. It is only slightly warm, but definitely not cold. It is very close to the neutral point in the warm-cool scale.

Tint No. 8, Aquagreen. A brilliant blue-green. The color of more northern waters and suitable to the rendition of the sea under clouds and in storm. It is suggestive of wetness. Its transmission (40 per cent) being lower than that of Verdante, it gives a less brilliant screen. This together with its greater blue tint probably makes it more suitable for the rendition of the darker green of mature foliage, dense forests of pine, jungles, etc. By extension from the objective correlation to summer it is suggestive of such mood reactions as pertain to maturity, wisdom, dignity, repose, and restfulness. It is cool but not cold; tranquil, but not subduing.

Tint No. 9, Turquoise. A clear brilliant blue. It is definitely cool, but less cold than Azure or Nocturne. The visual transmission (43 per cent) is high for a blue of this hue but low as compared to the warm colors. This gives a screen of depressed brightness which together with the hue tends to produce a mood of peace, reposefulness, and tranquility. It is the color of calm tropical seas under clear skies. It is suggestive of the Mediterranean and the South Sea Islands. If used on interiors it should impart a feeling of restfulness, dignity, and reserve without inducing appreciable depressive moods. With proper contextual influence it might be used for the suggestion of brilliant moonlight effects, although No. 10 may be somewhat better for this purpose.

Tint No. 10, Azure. A strong sky-blue. It is colder than Turquoise; tranquilizing to the point of becoming depressing. The visual transmission (28 per cent) is relatively low and hence gives a screen of low brightness. It is suggestive of the sedate and the reserved, even approaching the austere or forbidding; under certain conditions slightly gloomy.

Tint No. 11, Nocturne. Deep violet-blue. The visual transmission is low (28 per cent) giving a screen of low brightness. It definitely suggests night, shadows, gloom, coldness, etc. By subjective associational reactions appropriate to depressive conditions, despair, failure, unattained ambitions, intrigue, the underworld.

Tint No. 12, Purplehaze. A bluish-violet or lavender, rather pastel in character. It has a relatively high visual transmission (40 per cent) giving a screen of greater brilliance, higher key, than the adjacent tints, Nocturne and Fleur de lis, to both of which it is closely related in emotional value. The mood induced by this color is particularly dependent (more so than many of the other colors) upon contextual factors. For instance, to a twilight scene on the desert with distant mountains it imparts a feeling of distance, mystery, repose, and languorous warmth; used on a scene containing snow fields, glaciers, snow-capped mountains, etc., it has a pronounced cooling effect. The hue of this color is approximately the same as that of the shadows on sunlit snow under a clear blue sky.

Tint No. 13, Fleur de lis. A rich royal purple. This color has long been the badge of royalty, high office, power, and pomp. In ancient times the dye was very costly and was used to color the garments of the aristocracy. The transmission of this film tint is low (25 per cent), thus giving a depressed screen brightness suggestive of reserve, dignity, and austerity. It has a relatively cool color but not as cold as Nocturne.

Tint No. 14, Amaranth. This is also a purple but has a greater red content than Fleur de lis; therefore it is warmer and less austere. It is adapted to the rendition of scenes showing opulence and luxury together with refinement. With proper contextual relation it may be well adapted to scenes approaching sensuality and abandon, such as bacchanalian revels staged in settings of wealth, luxury, and elegance.

Tint No. 15, Caprice. Cool pink. Visual transmission (53 per cent) relatively high, thus giving a brilliant sparkling screen. It is a jolly, carefree, hilarious color suggestive of carnivals, Mardi gras, fête days, and merry making in general.

Tint No. 16, Inferno. Fiery red tinged with magenta. Since it is directly suggestive of fire, it is adapted to scenes of burning buildings, glowing furnaces, forest fires, etc. By subjective association indicative of riot, panic, anarchy, mobs, turmoil, strife, war, battle, and unrestrained passion.

Proper Use of Color on the Screen

It is not desired that the reader shall gain the impression from this rather enthusiastic discussion of the potential emotional value

of color that the lavish and unrestrained use of color treatments is advocated. On the contrary it is desired to emphasize the necessity of using the color accompaniment to a motion picture production with care and discretion. The use of too strong or saturated colors is in general not good, since such colors are usually obtrusive and distracting and may defeat rather than promote the attainment of the desired effect. A more subtle method will yield better results. This involves the employment of pastel tints which may be increased in subjective strength for a brief period of time by the action of successional contrast or juxtaposition in time. Thus the eye accommodated to, or fatigued by a green, such as Verdante, will perceive, at the beginning of the following scene done on a pink tint, a color of enhanced subjective saturation. This immediately fixes the mood of the scene, after which the accommodational processes in the retina begin to operate and cause the effective saturation to decrease appreciably. Thus the color having fulfilled its mission, saying definitely that this scene has a specific emotional atmosphere, fades into the background and while continuing to make itself felt in the subconscious mind of the observer by lending a warmth and softness to the scene permits the action to carry forward the dramatic sequence without the unpleasant and distracting influence of pronounced color.

There are perhaps some who may question the advisability of attempting to use color on the screen as an aid to the creation of an emotional atmosphere on the ground that individuals react differently to the same color. Is it not true that the same musical composition may excite different feelings in individuals, and that the same word or phrase may convey to different minds somewhat divergent ideas? Perhaps it will be necessary to spend much time and effort on the development of a language of color, to compile dictionaries with definitions of the symbolical, associative, and emotional values, just as we write and agree upon definitions of words in order that specific ideas may be conveyed from one mind to another by spoken and written language. If there is in the human mind, or, more specifically, in the collective mind of the motion picture public, a color consciousness, even though it be at present latent or but slightly developed, is it not worth considerable effort in thought and experimentation to develop a technic such that color can be applied to the screen in such a way as to enhance the emotional and dramatic values of the motion picture of the future?

REFERENCES

1. Ridgway. *Color Standards and Nomenclature.* 1912.
2. Loyd A. Jones. Trans. Soc. Mot. Pict. Eng. No. 18:15. 1924.
3. Loyd A. Jones and L. M. Townsend. Trans. Soc. Mot. Pict. Eng. No. 21:38. 1925.
4. Loyd A. Jones and Clifton Tuttle. Trans. Soc. Mot. Pict. Eng. No. 28:183. 1927.
5. George Field. *Chromatography.* Charles Tilt, 1835.
6. *l.c.* p. 11.
7. Opie's Lecture IV, p. 147.
8. Luckiesh. *The Language of Color.* Dodd, Mead and Company, 1920.
9. *l.c.* p. 4.
10. *l.c.* p. 200.
11. N. A. Wells. Psych. Bul. 7: 181. 1910.

MACHINE FOR CUTTING MASTER DISC RECORDS

L. A. Elmer* and D. G. Blattner*

THE machine used in recording sounds on phonograph discs synchronously with associated pictures consists essentially of a turntable, bearing the "wax" and rotated by a synchronous motor of constant speed, and an electrically driven stylus cutting the record. In the design of this machine the primary aim is to ensure that the record is both faithful to the original sounds and synchronous with the pictures. Fidelity in the performance of the stylus would be vitiated by departures from uniformity in the speed of the turntable while sounds were being recorded or reproduced. Although a constant speed motor is used, its value would be destroyed if the machinery transmitting the drive motor to turntable were not equally free of velocity variations. Thus the problem of fidelity involves not only the motor and the stylus but all the moving parts of the machine.

Turntable and Gear Drive

Even were it possible to connect the motor directly to the turntable, casual variations in the speed would arise, from varying frictional loads on the turntable and bearings. But direct connection is unsatisfactory. Because the turntable must operate at a lower speed than the motor (one thirty-sixth of that speed), reducing gears must intervene. In the actual apparatus, the motor drives (through a horizontal coupling) a worm engaging a worm wheel which drives (through a vertical coupling) the shaft to which the turntable is attached.

It is cyclic speed-change that must be guarded against in this mechanism; all such changes with frequencies from about one-half cycle per second up to the higher limit of audibility are to be avoided. Speed changes at audible frequencies introduce extraneous sounds into the records, and speed changes at frequencies below the audible range produce changes in pitch. There are in general two points of origin for these variations: the turntable and its bearings, and the gears. Speed-changing variations in load on turntable and bearings are most likely to have the frequency of the rotation of the

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turntable (a little more than one-half cycle per second). From the gears three sorts of variations arise: those accountable to inaccuracies in the spacing of the teeth (Figure 1), to errors in the shape of the teeth, and to the successive shifts of driving load from tooth to tooth. Together, these may occasion variations with quite a range of frequencies.

The extent to which these variations are permissible is determined, for low-frequency changes, by the smallest change in pitch

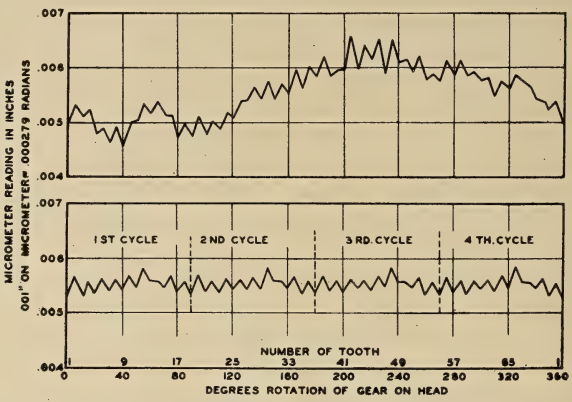


FIGURE 1. Above: difference between actual and correct positions of teeth on a typical gear, relative to an arbitrary reference position. Below: averaging effect of dividing same gear into four layers, calculated from data (above) for one layer.

the ear will notice when pitch-variation is continuous. It appears that, when a pure tone is projected by a loud speaker of high quality, the ear can detect variations in its pitch which exceed one-tenth per cent of its frequency. This sets a severe requirement for constancy of rotation.

It is, furthermore, an overall requirement, for it applies to differences between the original and reproduced sound; and both a recording and a reproducing machine intervene between these sounds. Since both operate at the same speed, and since there is a high probability that the ultimate record will be lined up on the reproducer correspondingly to the "wax" on the recorder, variations in the speeds of the two are likely to be additive in their effects upon sound pitch. The sum of the variations permitted in the two, therefor, must not be greater than the total permissible variation for the

system as a whole. Since the more its velocity characteristics are made constant the more the apparatus costs, it is economical to be stringent in requirements for constancy in the recorder, of which comparatively few are manufactured, the more lenient in those requirements in the more numerous reproducers. An economical division between the two machines of the total allowable error appears to be in the ratio of one to four. The demand for constancy thus placed upon the recorder is far higher than can be met by gears and

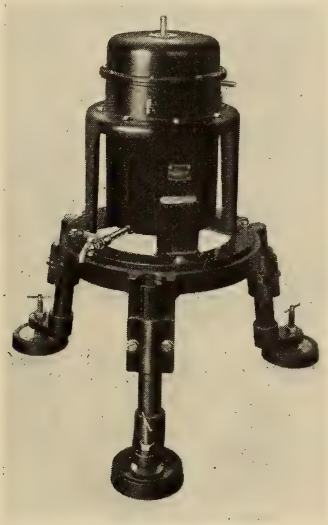


FIGURE 2. The mechanical filter for turntable drive, as it appears in a commercial disc-recording installation.

bearings of even the most careful construction. It is a demand which can be filled only by special means.

A motion of this sort can be treated as a uniform rotation on which a small reciprocal motion is superposed. The reciprocal component can be suppressed, therefore, by a vibration-absorber rotating as a unit with the entire apparatus and absorbing the relative reciprocal motion between its parts. This absorber, or "filter", can be made of masses, springs, and dissipative plastics, suitably combined in accordance with dynamic theory.

Special formulas have been developed for this type of drive based on vibration theory; and charts plotted therefrom showing the calculated velocity variation of the turntable from such data

as: number of gear layers used, tooth spacing errors, shaft friction, spring stiffness, degree of oil damping, and turntable inertia. These charts covering a range of values readily indicate the most suitable proportions for the fundamental elements of this driving mechanism, but they are too extensive to be given here.

Such a filter, designed in Bell Telephone Laboratories, is incorporated (Figure 2) in the Western Electric Company's commercial disc-recording apparatus. It uses coil-springs as its capacitances, viscous oil for its resistances, and the masses of its moving parts as

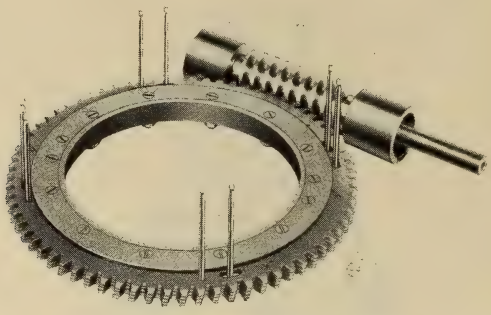


FIGURE 3. The reduction gearing: a worm and a four-layer worm-wheel.

its inductances. The great width of the frequency band to be attenuated, and the plurality of the sources of the varying force, considerably complicate the problem of determining what values of stiffness, weight, and dissipating ability should be used. For example, variations due to gear inaccuracies are most readily absorbed by very flexible springs, whereas disturbances due to varying loads are best prevented from affecting turntable speed by the use of stiff springs. The filter finally designed embodies a compromise between these conflicting demands. Its general construction is such that the worm-driven gear drives the turntable shaft through the linearly flexible springs, and relative motion of the gear and shaft is damped by the oil.

The gear (Figure 3) is made in four layers. These layers are clamped together when the teeth are cut, and each layer is afterwards rotated ninety degrees relative to the adjacent layer. All are finally mounted, in engagement with the worm wheel, so that each can move independently of its companions. To each layer two cross-braced posts are rigidly attached, from the tops of which (Fig-

ure 4) springs lead to lugs on a plate fastened to the turntable shaft. Thus each layer of the gear independently drives the shaft through

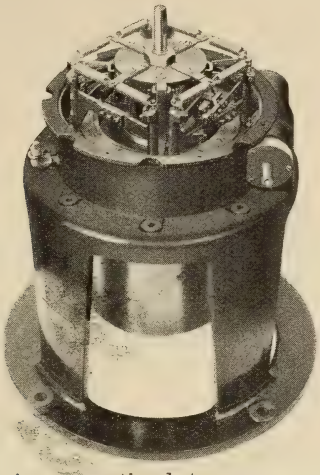


FIGURE 4. The spring connection between gear and turntable shaft.

two springs. It is apparent that the offset four-layer structure of the gear divides by four the amplitudes of the disturbances caused

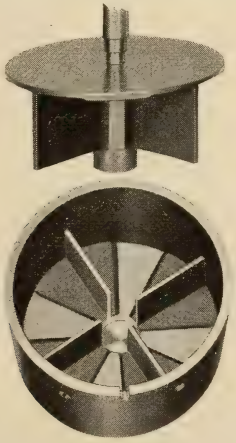


FIGURE 5. The oil-damping connection between gear and turntable shaft. Above, vane-bearing end of turntable shaft; below, oil cup.

by inaccuracies in the teeth, since at any one time, each affects but one of the four sets of springs. This structure also multiplies by

four the frequencies with which these disturbances occur since each inaccuracy in cutting is made to occur once for every 90 degrees, instead of once for every 360 degrees, of rotation. This higher fre-

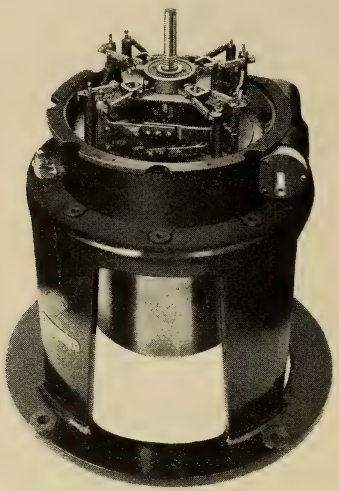


FIGURE 6. Linkage mechanism and its braces, through which the gear drives the oil cup.

quency is far more readily absorbed by the filter than the lower would be.

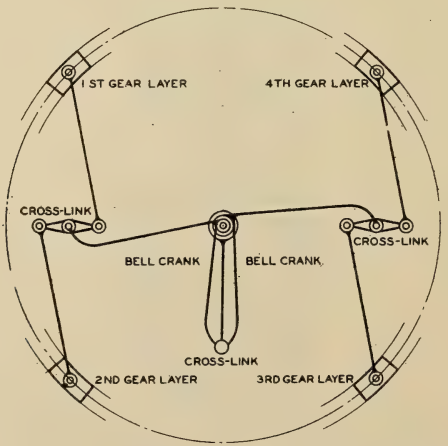


FIGURE 7. Schematic diagram of linkage. The bell-cranks are pivoted at the center of the mechanism but are not attached to the shaft. The third crosslink, between the ends of the bell-cranks, is perpendicular to the plane of the diagram. From its center extends the only member which has a rigid connection at the center of the mechanism, to the collar which drives the oil cup.

The oil connection between gear and turntable shaft is effected by permitting the layer-gear to rotate a vane-bearing oil-filled cup, into which dip vanes attached to the turntable shaft (Figure 5). The mechanism (Figure 6) through which the gear drives the cup is in this case rigid rather than elastic, but is again one whereby the effect of a gear irregularity upon the cup is quartered in amplitude and quadrupled in frequency. This mechanism is a system of links independently driven by each of the layers of the gear so as jointly to rotate the cup with the average velocity. To each layer, again

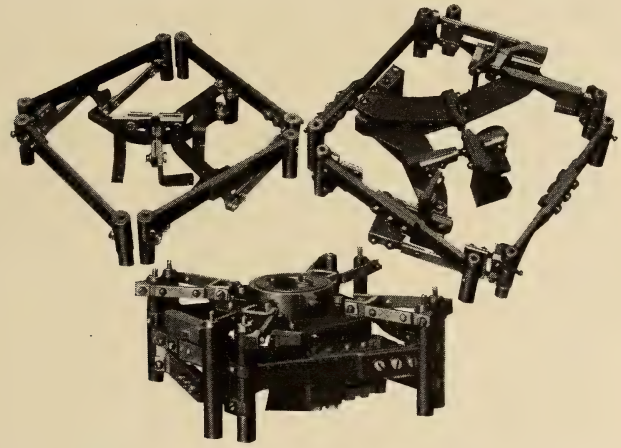


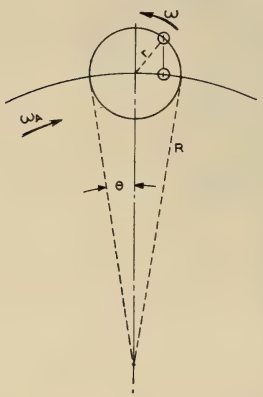
FIGURE 8. Steps in the development of the linkage, showing its successively more rugged construction.

through the perpendicular posts, is attached a link (Figure 7). The members of one and the other pair of these links are flexibly joined by cross-links, to the center of each of which is pivoted one end of the bell-crank. The other ends of these two bell-cranks are in turn flexibly joined by a third cross-link, to whose center the member which drives the cup is attached. It is apparent that the motion of the center of each cross-link is the average of the motions of its two ends. Each of the first two cross-links, therefore, averages the motions of two of the gear-layers, and the third cross-link averages the motions of the first two cross-links, driving the oil cup with the average motion of all four gear-layers.

Because the deflections with which this apparatus is expected to operate are very small, it is essential that no motion be lost by "backlash" in pivots. For this reason, and to minimize pivotal

friction, flat reed-springs are used for all joints. Since the linkage cannot be constructed in a single horizontal plane but must be built in several planes, it is subject to warping forces which tend to produce many undesired motions. To avoid these, the linkage is extensively braced (Figure 8).

In the development of this filter, reliance upon theory had to be supplemented by measurements of the effectiveness of various models. Since smooth rotation of the turntable was in view, fluctuation in turntable speed was the performance to be directly measured. This was accomplished stroboscopically. On the rim of the



ω_A = Av. Turntable Vel.

$\omega_A + \frac{\omega_r}{R}$ = Max. Turntable Vel.

$\omega_A - \frac{\omega_r}{R}$ = Min. Turntable Vel.

ω = Angular Velocity of Vibration = $2\pi f$.

$2\frac{\omega_r}{R}$ = Velocity Varation

$200\frac{\omega r}{\omega_A}$ = Velocity Var. in per cent

$200\frac{\omega_r}{\omega_A R} = 200\frac{\omega}{\omega_A}\theta$

θ = Amplitude in Radians

When $\frac{\omega}{\omega A} = 1$, $\qquad 200\frac{\omega_r}{\omega_A R} = 200\,\theta$

FIGURE 9. Method of converting stroboscope micrometer reading to per cent velocity variation. The curve of large radius represents the rim of the turntable, and the curve of small radius represents the familiar diagram of harmonic motion. At the projection of the end of the small circle's radius is a groove on the turntable rim. The quantity read on the micrometer is 2r—the maximum apparent motion of a groove.

turntable 216 accurately spaced grooves were cut. A disc, with six radical slots, was connected by a rigid drive to the shafts of the synchronous motor. The disc was so placed that the grooves on the rotating turntable could be observed one by one by a microscope looking through the slots in the rotating disc. Observed through this apparatus, the groove on the edge of the rim appears to stand still when the speed of the turntable is exactly one thirty-sixth the speed of the motor. A small error in turntable speed causes the image of the groove to change position momentarily. The amount of this shift can be read in thousandths of an inch on a filar micrometer

placed in the eyepiece of the microscope. From this reading the per cent velocity variation can be calculated (Figure 9).

The model finally developed drives the turntable with remarkable constancy. Of the velocity variations from the two major sources of error—from varying loads, at one cycle per revolution, and from varying gear-spacing, at four cycles per revolution—the former has been reduced to 0.04 per cent and the latter to a point below the limit measurement. Supplemented by suitably modeled drives for reproducing machines, recording drives of this type provide ample insurance against maltreatment of sounds by driving machinery.

The purpose of the turntable and other gear described is of course only the means to an end. They are essential in order that the recording instruments may perform their intended function.

The recorder and reproducer, the instruments referred to have been described in previous literature* but further discussion in regard to certain features of design and usage may be of interest at this time.

Recorder

The technical features of the recorder will be considered only in so far as is necessary to bring out the points under discussion.

For present purposes, the transmission system used in disc recording can be described as a transmitter directly connected to a recorder. In such a case, the transmitter (microphone and other transmitting apparatus) used for picking up the sound, may be considered as a constant resistance device which, when subjected to sound pressure waves, generates an alternating voltage proportional in magnitude to the sound pressure and of the same frequency; and the recorder may be considered as a device actuated by such a transmitter to produce an engraving in a wax, the wave form of the engraving having the same frequency as the transmitter voltage.

It is obvious that in such a system only a portion of the transmitter voltage is effective to drive the recorder. It is necessary that the recorder should produce an engraving that bears some simple relation to the transmitter voltage, since this voltage is proportional to the sound pressure. With a perfect recording and reproducing system, the sound power reproduced from the record would

* Maxfield and Harrison in A.I.E.E. February, 1926.
Frederick in Journal of Motion Picture Engineers, Sept., 1928.
Frederick in Bell Technical Journal of January, 1929.

be proportional to the sound power available for recording; and if the air load on the sound reproducer (or loud speaker) is of the constant resistance type, then the simple relation between the performance of the recorder and the transmitter voltage referred to above may be expressed as

$$V = K\nu. \qquad (1)$$

Where V is the transmitter voltage ν is the vibrational velocity ($2\pi fa$) of the engraving and K is a constant. Except as other considerations* make it necessary to depart from such a relation, this equation then may be taken as the required performance characteristic of the Western Electric D-85264 type recorder.

It will be obvious from equation (1) that the factor K can have any value and still fulfill the requirements as to perfection of performance; the only further requirement in this respect is that a suitable value of ν shall result from the combined action of the transmitter and recorder to make the subject matter of the record stand out sufficiently above the incidental noise. In other words, K merely indicates the combined transmitter and recorder sensitivity required for a given sound loudness available for recording. If the transmitter sensitivity can be varied at will, then the recorder sensitivity can be allowed to vary, provided the magnitude of the variation does not impose additional requirements on the transmitter. In the case of the Western Electric recording system, the 394 transmitter and associated amplifiers are considered as the transmitter device, discussed above, and are readily adjustable as to sensitivity. There is therefore no need of the recorders being alike in sensitivity, and, as a matter of economy in manufacture, no considerable effort is made to have them so. In fairness to the recorder however, it might be said that the magnitude of the manufacturing variations permitted is so small that the device would have been considered uncommercial a few years ago.

From what has been said, it probably has occurred to the reader that variation in sensitivity if the recorder product is of less importance than variation in shape of the sensitivity characteristic for various frequencies. It is distinctly desirable that the same quality of reproduction be obtained from records cut by different instru-

* As pointed out by Frederick the required playing time of a record of given size makes it necessary to reduce the amplitude of cut at low frequencies if maximum loudness is to be obtained.

ments. To this end, a variation in shape of the sensitivity characteristic of any recorder, throughout the frequency band of interest in excess of ± 1 db,* is not permitted; whereas, a variation of ± 3 db between different recorders at any particular frequency is

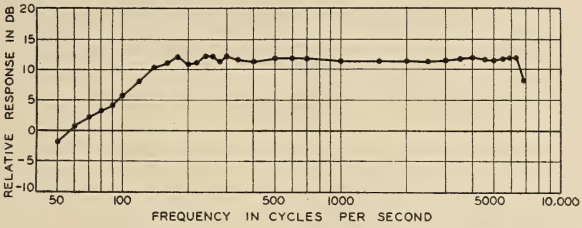


FIGURE 10. Typical response characteristics of D-85264 recorder.

considered satisfactory. Figure 10 shows a typical sensitivity characteristic of the D-85264 recorder.

In order to obtain such a degree of precision in sensitivity of recorders manufactured by the Western Electric Company, it has been found necessary to go to some considerable pains in assembly

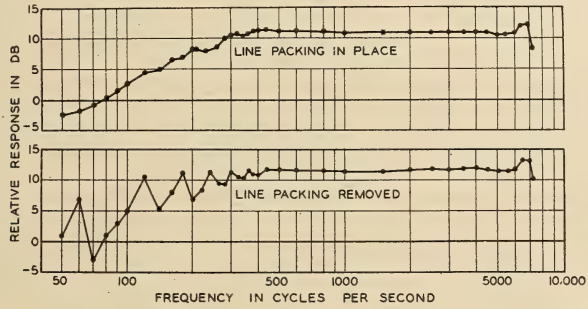


FIGURE 11. Effect of removing packing from D-85264 rubber line recorder.

and adjustment. For instance, the rubber line must be carefully chosen as to mechanical properties and must be carefully packed in the housing. Once properly assembled and adjusted however, experience with a considerable number of recorders now in service indicates that further attention is rarely necessary, provided the instruments are handled with reasonable care. Proper selection of

* Except at low frequencies where the limitation in regard to length of rubber line makes it desirable to allow a variation of as much as ± 2 db.

the rubber line and proper assembly and adjustment are determined by sensitivity measurements at various frequencies rather than by visual observation, and under no consideration is it recommended that adjustments or repairs affecting the rubber line be attempted in the field. Fig. 11 shows the effect upon sensitivity caused by improper packing of the rubber line.

A further point in this connection has to do with the stylus. The recorder was designed to be used with an average cutting point weighing about 25 milligrams. It is obvious that if the point is not of the proper weight or if it is not mounted in proper relation to the stylus arm, a typical response curve cannot be obtained. Fig. 12 shows the effect of the weight of the recorder point upon the shape

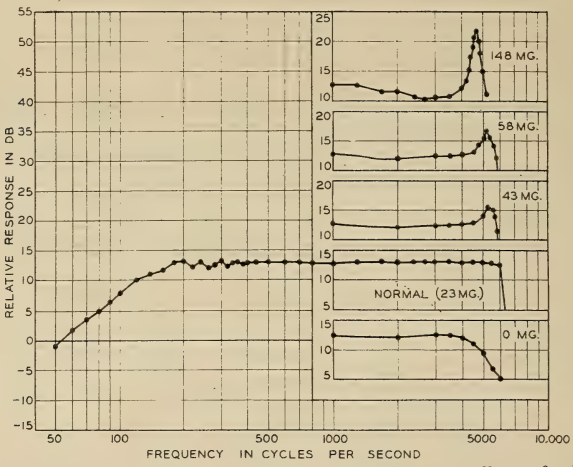


FIGURE 12. Calibrations of electrical recorder showing the effect of adding mass to the tip of the stylus arm.

of the sensitivity characteristic of the device. The proper mounting of the stylus point is one for which the tip extends beyond the end of the stylus arm from 1/16 to 1/10 of an inch.

In order to facilitate determination of the sensitivity of the recorder at various frequencies, a new calibrating system has recently been designed which replaces the optical apparatus previously used for this purpose. The use of the new system involves only such technique as is already familiar to amplifier maintenance people. The scheme consists in replacing the stylus point by a small coil of equal effective mass, operating in the gap of a magnet in such a way

that the motion of the stylus arm induces a voltage in the coil proportional to the velocity of the arm. The technique of making a response determination consists in comparing the coil voltage to the

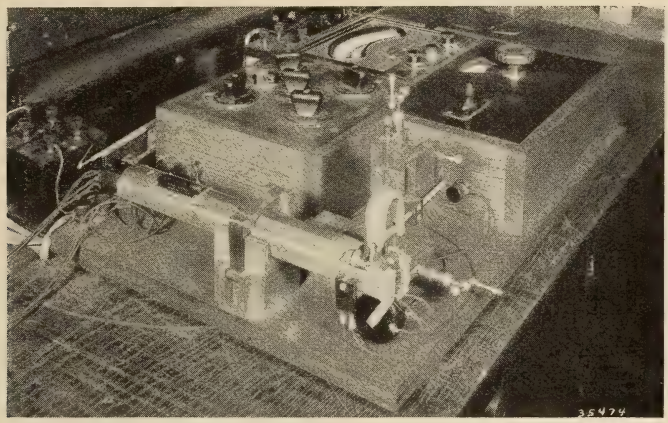


FIGURE 13. Recorder being tested in calibrating set.

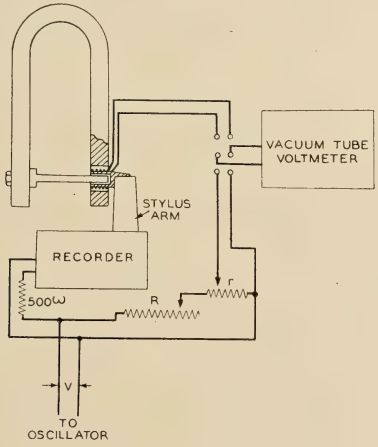


FIGURE 14. Schematic of recorder calibrating circuit.

transmitter voltage in much the same way as in the measurement of amplifier sensitivity. Fig. 13 is a photograph showing the recorder and calibrating coil assembly, and Fig. 14 shows a schematic diagram of the calibrating circuit. It will be obvious from the last figure that the response measurement does not depend upon the magnitude

of the transmitter voltage (V, Fig. 14), and that since the coil voltage is proportional to the velocity, rather than to the amplitude of the stylus, the new method is more accurate and also more rapid than the optical method.

In connection with the calibration of recorders it is important to know something as to the purity of the wave form of the groove cut by the recorder. A considerable harmonic content in the wave form might defeat the whole purpose of the calibration. In consideration of this point, it is to be expected that in a magnetic system, in which all the reluctance is concentrated at the air-gap and in which a preponderance of the total armature flux results from the steady magnetomotive force, a condition of saturation would result when the gap is momentarily reduced a sufficient amount. In the Western Electric recorder, considerations as to the flux density in the gap and permeability of iron lead to the conclusion that the harmonic generation would be small for stylus displacements of as much as 10 mils or more, whereas the maximum displacement permissible from the standpoint of the record is only about 2 mils. Experimental data indicates that when driven at a frequency of 50 cycles and an amplitude of 4.6 mils the harmonics are of the order of 30 db below the fundamental.

In connection with the D-85264 recorder, a new feature has recently been worked out by means of which it is now possible to monitor from the stylus arm rather than from the bus bars of the amplifier which feed the recorder. As pointed out, the response of the recorder at low frequencies is somewhat less than at the higher frequencies, and therefore the character of the monitoring reproduction by the two methods will be different. By monitoring on the stylus arm, it is now possible to hear, when recording, what the finished hard record, made from the wax being cut, will be like. It is felt that monitoring in this way should make it possible to more accurately judge the balance of the subject matter and so result in a more uniform product and in saving of time and expense. The monitoring device consists of a coil and magnet similar in construction to those described for the response measuring system, but differing, in that the monitoring apparatus is supplied to the stylus arm at a point about midway of its length. In applying the monitoring device to a recorder it is necessary to alter the stylus arm somewhat in sectional area and in length in order to obtain the proper overall effec-

tive mass; but the effect of the alternation upon sensitivity is negligible. Fig. 15 shows a recorder to which the monitoring feature has been applied, and Fig. 16 shows a response characteristic of such

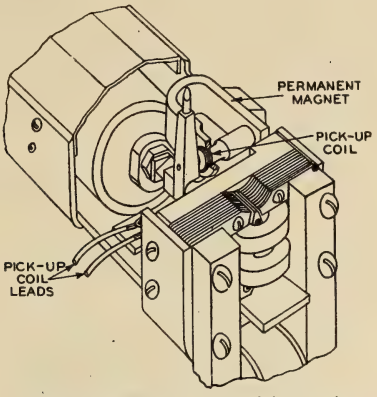


FIGURE 15. D-85264 type recorder with monitor attachment.

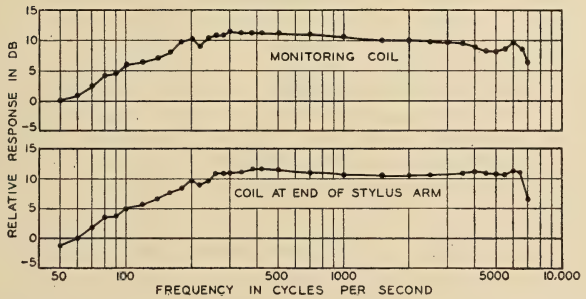


FIGURE 16. Frequency response characteristics of recorder measured by monitoring coil and by similar.

a recorder, when measured in the usual manner and also when measured by means of the monitoring device. It will be obvious that the relative response of the recorder when measured at the end of the stylus arm and when measured at the monitoring coil position are practically identical.

6-A Playback Reproducer

The 6-A playback reproducer is a device for playing back from wax engravings for purposes of inspection and observation as to the

perfection of the work. It is not intended that the engraving so used shall be preserved for making finished records, although this has been done at various times with reasonably satisfactory results.

The transmission characteristics of the 6-A reproducer have been described in literature previously referred to, but no detailed description of the device has been given. Briefly, it may be described as a balanced armature electromagnet device in which an armature, mounted on a steel diaphragm, is free to rock about a diameter as a pivot, under the influence of the needle-driving member as shown in Fig. 17. Wings extend laterally from the armature in such

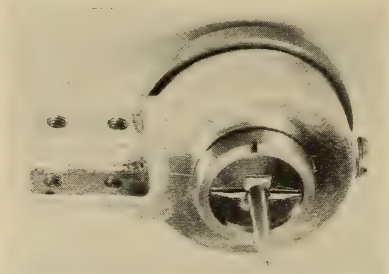


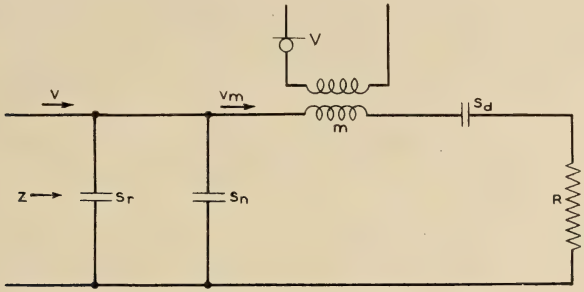
FIGURE 17. No. 6-A reproducer showing armature and tracking point.

a way as to prevent the diaphragm assembly from moving in the characteristic diaphragm or piston manner. A motion of the armature in the magnetic field causes the induction of a voltage in the windings surrounding the inner pole tips, which induction is proportional to the velocity of the armature and is the sole function of the reproducer device. One of the features of the 6-A reproducer is the oil damping, provided to prevent the armature velocity and the needle point impedance* from rising to relatively large values for frequencies at, or near, resonance.

From a transmission point of view, there are two important considerations that must be met in order that the playback reproducer may be considered satisfactory. These are: first, that the device shall be capable of tracking the wax groove without destroying it to the extent that the reproduced sounds do not faithfully represent the recorded material; and second, that the voltage, developed by the device, shall be proportional to the velocity of the record groove for all frequencies of interest.

* Mechanical impedance of the moving system to vibrational forces at needle point.

The 6-A reproducer may be considered as a structure analogous to an electrical circuit of the form shown in Fig. 18, to which a constant current is supplied by the record groove.



V = GROOVE ANGULAR VELOCITY
V_m = ARMATURE VELOCITY
V_m/V = CONSTANT
M = EFFECTIVE MASS OF ARMATURE NEEDLE
R = DAMPING RESISTANCE
S_d = DIAPHRAGM STIFFNESS
S_r = STIFFNESS OF WAX
S_n = STIFFNESS OF NEEDLE

$$S = \frac{S_r S_n}{S_r + S_n}$$

ALL VALUES EFFECTIVE AT GROOVE

FIGURE 18. Electrical analogy of 6-A reproducer.

Assuming that the various constants in the figure are the equivalent values measured at the needle point, the two conditions above may be stated mathematically as follows:

$$\frac{V_M}{V} = \frac{S}{(S + S_d - w^2 m) + jRw} = \frac{1}{C} \tag{2}$$

$$Z^* = S\frac{[(w^2 m - S_d) - jRw]}{Rw^2 + jw\,[w^2 m - (S + S_d)]} < \frac{EA}{V} \tag{3}$$

Where E is the maximum permissible stress of the wax, A is the area of the bearing surface of the needle in the groove and C is a constant. Assuming that for any frequency of interest S is greater than w^2m, it is obvious from equation (2) that V_m/V will be maximum when Sd is negligibly small in comparison with S.

It is of course impossible in a structure of the type shown, to satisfy equation (2) to the extent of making C absolutely constant;

* Mechanical impedance of the vibrating system including the yielding of the wax walls.

but for some limiting value of C, it can be shown on the above basis that the natural frequency* of the device when critically damped is

$$f_o = \frac{\sqrt{\frac{S}{m}}}{2\pi} \sqrt{C-1} \qquad (4)$$

It can be shown that the response of a structure as shown on Fig. 18 will decrease rapidly after the natural frequency is past, and therefore, that the natural frequency should be at, or near, the upper limiting frequency of interest. It will also be clear (from equation (4)) that S should be made as large and m as small as possible.

From Fig. 18 it is evident that in S, only the needle stiffness component (S_n) is under the control of the instrument designer, so that the value of S may vary throughout wide limits, depending upon the stiffness characteristic of the record material. That the stiffness of the needle used in the 6-A reproducer is large, in comparison with the stiffness of the wax, is indicated by data to the effect that the resonant frequency of the device on hard records is about four times as great as on waxes. It is therefore quite probable that the factor S in equation (4) is about as large as it can readily be made.

The alternate method of obtaining a high natural frequency by reducing m to a minimum can be accomplished in either of two ways: by actually reducing the amount of material used, or by disposing the material in such a manner as to offer a minimum impedance to motion of the needle point. In regard to the amount of material used, the needle of the 6-A reproducer is a hollow conical structure, the walls of which are about .002″ thick, while the iron used in the vibrating system has been reduced to the minimum required to carry the flux. Further reduction in the needle wall thickness would probably be impractical, and further reduction in the amount of iron would necessitate a corresponding reduction in the output voltage or would result in an impure voltage wave. As to disposition of materials, the driving needle has been designed as an impedance step-down transformer of such a ratio that efforts to further increase the ratio are not successful on account of the increased amount of needle material required. The mass of the diaphragm and armature contribute only a small per cent of the total impedance effective at the point.

* By natural frequency of a critically damped system is meant the limiting value as R approaches 2.

So far as mechanical impedance of the reproducer is concerned, there probably is a considerable variation in the elasticity of waxes available at the present time, and the only safe procedure is to make Z (equation (3)) as small as possible. For the condition set up for equation (4) the needle point impedance for different frequencies may be expressed as

$$Z_{min.}\ f = 2\sqrt{mS} + j\,wm \tag{5}$$

$$Z_o = {}^1/_2\sqrt{mS} - j\frac{S}{w_o} \tag{6}$$

Where $Z_{min.f}$ refers to the impedance at the natural frequency, which interest and Z_o is the impedance at the natural frequency, which as brought out should be the impedance at or near the maximum

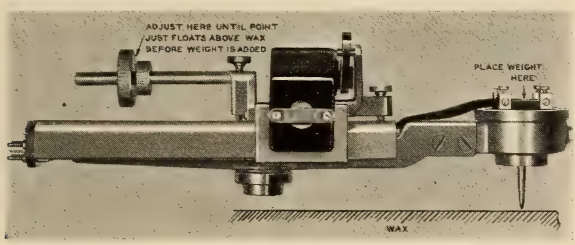


FIGURE 19. Proper method of adjusting No. 6-A reproducer to wax play back.

frequency of interest. It will be obvious from these equations that the impedance approaches the limiting values of $2\sqrt{mS}$ and $\frac{1}{2}\sqrt{mS}$ as the two limiting frequencies are approached. It is therefore clear that reduction of m in order to increase the width of the response band is also effective in reducing the impedance of the vibrating system. From equations (5) and (6), and certain mass and stiffness data available, it appears that the impedance of the 6-A reproducer, throughout the band of frequencies of interest, might be as great as 1200 dynes sec./cm., which for a velocity of 4* cm./sec. is equivalent to a lateral force of approximately 5 grams against the wax walls. It is of interest to note that the effective weight of the reproducer on the bottom of the groove should be of the order of 5 to 15 grams in order to obtain satisfactory tracking, and that for this weight the bearing surfaces of the needle in the groove are such that the ratio of lateral pressure to vertical pressure may vary

* Corresponding to an amplitude of about .001″ at a frequency of 250 cycles.

between limits of 1 and 5 depending on the set up. It is to be expected therefore that any trouble of tearing the wax is probably due to excessive lateral pressure. For this reason, it might be desirable to cut the playback waxes at a somewhat lower level than the waxes that are to be used for pressings. This would also reduce the required weight on the bottom of the groove. With waxes cut at normal recording levels, however, we have found it possible to obtain satisfactory tracking with a weight on the needle point of as little as 5 grams, and with such a setup it is possible to play a wax several times without a noticeable change in quality or noise.

In connection with the question as to the proper effective weight of the reproducer on the bottom of the groove, may we call attention to the method by which the weights used were determined. It consists in balancing the device so that the needle point just barely clears the surface of the wax, after which, a weight of the proper amount is placed on the reproducer directly above the needle as shown in Fig. 19. The scheme is reliable and convenient and we see no reason why it should not be used in the recording field.

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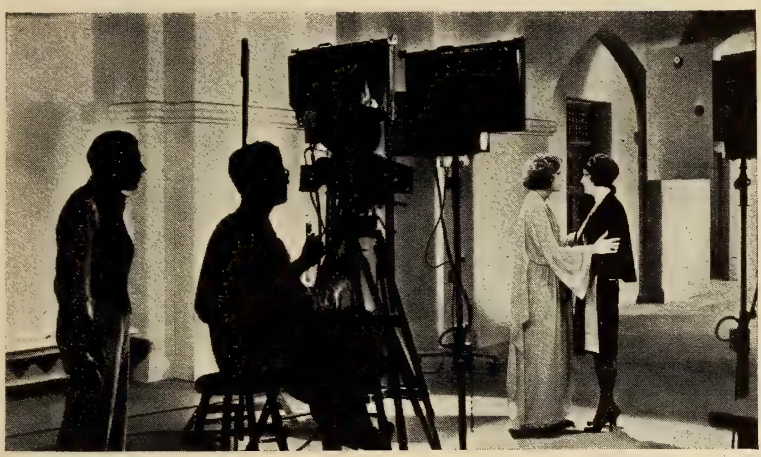

GRETA GARBO *and Dorothy Sebastian in a scene from "A Woman of Affairs," Clarence Brown directing. Courtesy of Metro-Goldwyn-Mayer*

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A REPRODUCING MACHINE FOR PICTURE AND SOUND

H. PFANNENSTIEHL*

THE Western Electric theatre reproducing machine provides for reproducing sound from both disc and film records in synchronism with the showing of motion pictures.

The machine, now being installed in theaters for this purpose, consists in general of a base on which is mounted a motor, a disc

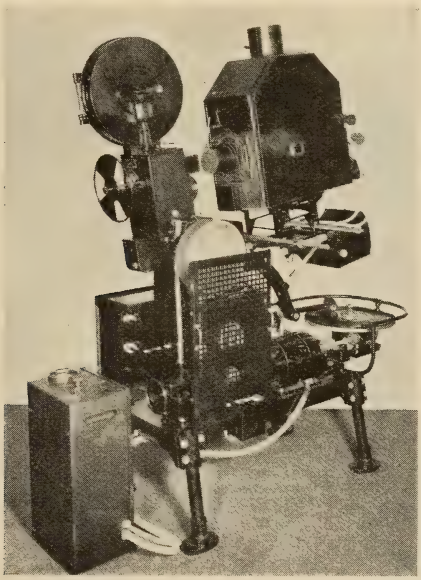

FIGURE 1.

record reproducing unit, an optical sound unit for reproducing sound from film and a film take-up mechanism with the necessary gearing and shafting to connect these mechanisms to the motor shaft. This machine is also arranged so that with suitable adapters and gear drives it will mount and operate practically all commercial projector heads. At the present time the Simplex, Powers, Motiograph, Superior and Holmes projector heads are provided for.

* Bell Telephone Laboratories, Inc., New York, N. Y.

Figure No. 1 shows the operating side of this reproducing machine equipped with a Simplex projector head.

Motor Drive

The motor used to drive this machine can be run with its speed very accurately controlled at 1200 R.P.M. corresponding to a film speed of 90 feet per minute or can be run at various speeds between 900 and 1500 R.P.M. corresponding to film speeds of 68 to 112 feet per minute. The variable speed control of this motor is employed for the projection of silent pictures where it is often found desirable to run the film at speeds either above or below the normal of 90 feet per minute. When used to drive the machine for synchronized

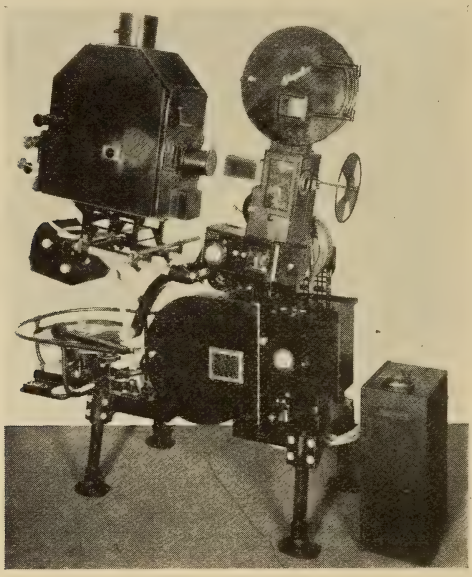

FIGURE 2.

sound picture purposes the motor speed is controlled by means of a vacuum tube type of regulator to an accuracy of plus or minus 0.2% over normal variations in line voltage and load. Two forms of this motor with its regulator are provided, one for direct current and one for alternating current operation. In addition to regulating the speed very closely the vacuum tube regulator prevents hunting or surging of the speed of the motor. This motor with its regulator was described in detail by Mr. H. M. Stoller at the Lake Placid meeting of the Society of Motion Picture Engineers during Septem-

ber, 1928 and is included in Volume XII, No. 35, of the transactions of this society.

Synchronism

It is, of course, necessary to always maintain absolute synchronism of sound reproduced from either a disc or film sound record with the projection of motion pictures. This is accomplished by direct coupling the disc and film reproducing mechanisms and the projector head to the same motor shaft.

Figure No. 2 is a view of the drive side of the machine showing the various mechanisms connected to the motor through shafts and gearing.

Disc Reproducing Unit

The disc reproducing unit consists in general of a worm and wheel reducing gear, running in oil, connecting a turntable for mounting a disc record, to the motor shaft. The ratio of the gearing is such as to rotate the turntable at a speed of 33-1/3 R.P.M when the film is running at 90 feet per minute or twenty-four pictures per second which is the speed standardized for sound picture purposes.

The complete unit is mounted at the rear of the base directly under the projector arc lamp. In this position it is accessible to the operator and permits the easy replacement of records and the location of the sound pick-up reproducer on the record without the necessity of moving very far from the projector operating position. By mounting this unit on the base in this position instead of on the floor as is the usual practice it is possible to arrange the machines so as to take a minimum amount of floor space which is generally at a premium in theatre projection booths. Another advantage gained by mounting the turntable on the machine instead of on a separate pedestal adjacent to the machine is that of keeping the turntable drive shaft properly lined up with the motor shaft.

It is essential that the mechanical gearing from the motor shaft to the turntable be so designed that mechanical vibrations and irregularities in the manufacture of the gears shall not cause fluctuations in the velocity of the turntable of a magnitude great enough to distort the reproduced sound to an extent that affects its quality to a noticeable degree. A distortion due to this cause produces what is known as "flutter." Even with the most accurately made gears it has been found impossible to keep this "flutter" down to the desired

amount when the gear and turntable are directly coupled. It becomes necessary therefore to introduce some means of absorbing and eliminating the gear inaccuracies and instantaneous motor speed changes so that they do not seriously affect the velocity of the turntable.

This has been accomplished by means of a mechanical filter system introduced between the last gear and the turntable. This filter system is shown on Figure No. 3.

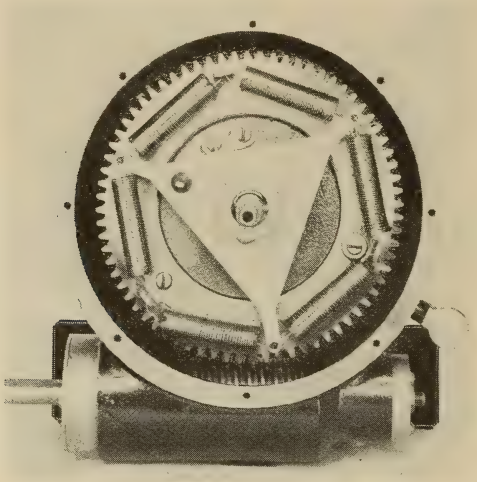

FIGURE 3.

This mechanical filter involves a flywheel and a flexible connector between the flywheel and drive gears. The turntable disc acts as a flywheel and the flexible connector consists of a series of six springs connecting the last gear to the turntable. By properly proportioning the moment of inertia of the flywheel and the flexibility of the springs the "flutter" is smoothed out to a point where it is not noticeable.

To avoid surges in this filter system and a persistency of any oscillation of the turntable, it is necessary to apply frictional damping to the spring connections. This is accomplished by wrapping each spring with a layer of felt which is kept in contact with the convolutions of this spring by means of a second spring wound around the outside of the felt. A layer of thin flexible metal is inserted between the outer spring and the felt to prevent this spring from

imbedding in the felt and interfering with the proper action of the inner spring.

These turntables are given a stroboscopic test to insure that they are free from oscillations to a degree within the limit at which noticeable pitch changes would occur. In this test the turntable is rotated at its correct speed by means of a very accurately regulated and smooth running motor. A 16-inch diameter ring, the periphery of which is divided into 216 accurate spaces is mounted on the turntable and a shutter disc having six radial slots is mounted on the motor shaft. This apparatus is then arranged so that the lines on the turntable ring can be observed through the slots in the shutter disc. If the turntable is rotating at an absolute uniform velocity the lines on the periphery of the ring appear to be stationary when observed this way. It has been determined that an observed movement of 0.012 inch of this line can be permitted if this movement does not occur more than once per revolution of the turntable. Turntables manufactured to operate within these limits will reproduce sound without a noticeable pitch change on a sustained note. Tests we have made showed that oscillations present in new turntables are materially reduced as the gears and bearings of the unit become worn in from continuous running.

The use of a Neon lamp flashed at the proper frequency to illuminate the lines of the disc in order to make this same stroboscope test has been tried but found to be impracticable for this fine measurement as the lines on the turntable disc are very much blurred when observed this way. With the shutter method the lines appear sharp and distinct and are easily measured when observing them by means of a low power microscope with an eyepiece having a graduated scale.

As a further precaution against gear irregularities being transmitted to the turntable, the gear and turntable shaft which are concentric are run in separate bearings. It was found that if the turntable shaft and the gear are in contact with each other while running, irregularities in the velocity of the gear are transmitted to the shaft to an extent sufficient to produce some flutter in the reproduced sound. Also, the turntable shaft is carried on a ball thrust bearing running in oil in order to keep the bearing friction as low and uniform as possible. Figure No. 4 shows a cross section of the turntable mechanism.

If any gear or other mechanical noise is transmitted to the disc record it may be picked up by the reproducer unit and appear as noise in reproduction. To insure that these units do not contribute an appreciable amount of noise they are compared to a standard unit which produces the maximum allowable noise. All units are made to run at least as quietly as this standard.

Some vibration is present in the machine proper due to the running of the motor, projector head and other mechanisms. To

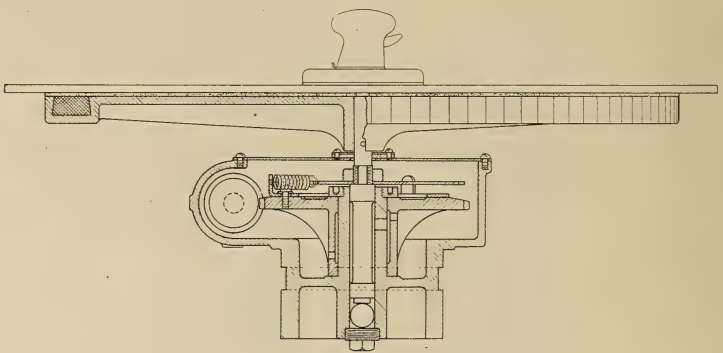

FIGURE 4.

prevent any appreciable amount of these vibrations from reaching the disc record or reproducer, the complete turntable assembly is mounted on a soft rubber pad. The shaft connecting the motor to the turntable is equipped with two rubber couplings to prevent motor vibrations being transmitted to the turntable through this shaft. These rubber couplings also act as universal joints to take care of any slight misalignment of motor and worm gear shaft.

The sound pick-up reproducer used with this turntable is extremely sensitive to mechanical vibrations. In order to prevent any appreciable amount of these vibrations from being transmitted to the reproducer, cushioning is provided between the bracket that supports the reproducer arm and the reproducer arm pivot.

Record Clamp

In order to prevent any possibility of the disc record slipping on the turntable, thereby destroying synchronism between sound and picture, a clamp is provided to hold the record firmly in position. This clamp is self-locking on the record locating pin and is readily removable by lifting a small latch.

Gear Drives

The end of the motor shaft opposite to that connected to the disc reproducing unit is connected through a self-aligning coupling to a main drive gear unit. This gear unit contains a main shaft which is coupled through three sets of bevel gears to one horizontal and two vertical shafts. The gears used in this drive are very accurately made and run in oil to produce smooth and quiet operation.

One of the vertical shafts of this gear unit is connected through a universely jointed telescoping shaft to a gear drive unit which is designed to mesh in with the gearing of the particular projector head to be used. A separate gear drive is provided for each of the projector heads listed in the second paragraph of this paper due to the fact that the gear ratio and method of connecting is different on each of these heads. The shaft is made telescoping so that its length can be varied and is built up with two universal joints to enable it to be adjusted to suit the various tilts and positions of the projector heads.

The other vertical shaft on this drive unit is connected through a self-aligning shaft to a set of gears that drive the sound sprocket in the sound film reproducing unit to be described later.

The horizontal shaft extending through this main drive unit is connected through a chain and sprocket drive to a film take-up mechanism and a hold-back sprocket mechanism mounted in the lower film reel housing.

The film take-up mechanism consists of a shaft on which the film reel is mounted which is driven by means of a friction disc type of clutch. The take-up tension on the film is adjusted by varying the tension on a spring used to keep the clutch discs in contact with each other. This arrangement is similar to that used on motion picture projectors.

Projector and Lamp Bracket

Mounted on the top of the film magazine casting is a pivoted bracket which is arranged to mount the projector head, the projector arc lamp, and the sound film reproducing unit. This bracket pivots about the center of the sound sprocket shaft and can be swung so that projection angles from horizontal to a downward tilt of 40° can be obtained. A jack screw is provided so that this bracket can be adjusted to the required projection angle by means of a handwheel. Stop nuts, one above and one below the handwheel, are

mounted on this jack screw so that the projection angle can be readily adjusted to a predetermined upper and lower position. This feature is useful where two screens are used in a theatre, one located ahead of the other and when it is desirable to be able to quickly change the projection angle so as to project the picture from one screen to the other.

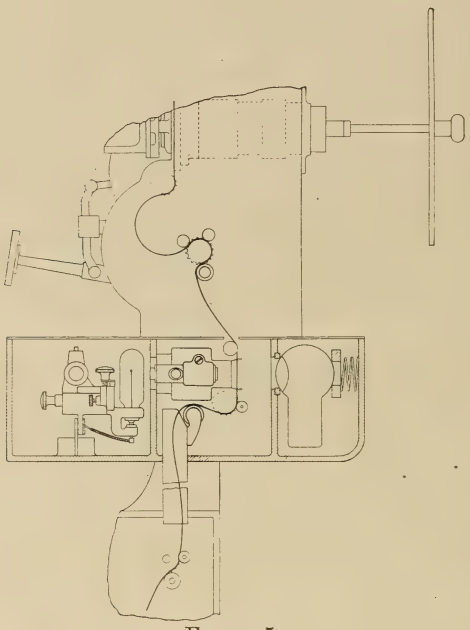

FIGURE 5.

Sound Film Reproducing Unit

Mounted directly beneath the projector head on the pivoted bracket is the sound unit intended for reproducing sound from a sound picture film. This unit is so positioned in respect to the projector head that sound picture film can be threaded through the machine to keep the sound (which is spaced on the film 14½ inches from the corresponding picture) in synchronism with the picture.

This sound film reproducing unit consists in general of a sprocket for pulling the film by an aperture plate at a uniform velocity, an exciting lamp for illuminating the sound track on the film, a lens system for focusing the light from this lamp onto the film, and a photo-electric cell. This arrangement is shown on Figure No. 5 in schematic form.

A loose loop of film is maintained between the lower sprocket in the projector head and the sound aperture so that the irregularities in the movement of the film caused by the projector mechanism are prevented from affecting the sound reproduced from this film.

It is just as essential to have the film as it passes the light in the sound unit move with a uniform velocity as it is to have the turntable rotate at a uniform velocity. Therefore, it has been found necessary to introduce a filter system between the sound sprocket and its driving gears very similar in operation to the one previously described for use with the turntable. However, this filter system

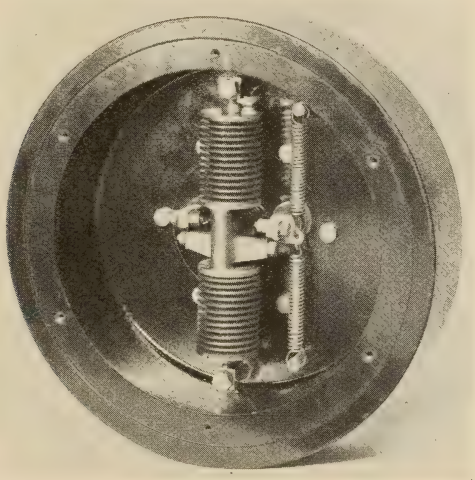

FIGURE 6.

differs from that used with the turntable in that hydraulic instead of frictional damping is employed. This hydraulic damped filter system is shown on Figure No. 6.

This filter system consists of a flywheel with a spring and hydraulic damping connector between the driving gears and the flywheel. The springs act to absorb velocity variations due to inaccuracies in the driving gear and motor speed. By properly proportioning the moment of inertia of the flywheel and the flexibility of the springs, velocity variations due to inaccuracies in the gearing that drives this mechanism are prevented from noticeably affecting the uniform rotation of the sound sprocket.

The hydraulic damping mechanism consists of two metal bellows filled with oil and connected so that they operate together with one expanding and the other contracting when the flywheel tends to

oscillate due to any acceleration or deceleration of the speed of the drive. Whenever this happens the oil flows from one bellows into the other through a small orifice. The size of this orifice is such as to offer sufficient resistance to the flow of the oil to adequately prevent the flywheel from oscillating to a degree that will cause a noticeable pitch change on a sustained note. Air in the bellows would impair the proper functioning of the damping effect and therefore extreme care is used in filling the bellows with oil to extract all the air possible.

It has been our experience that this filter system will prevent a noticeable "flutter" of the reproduced sound despite any minor

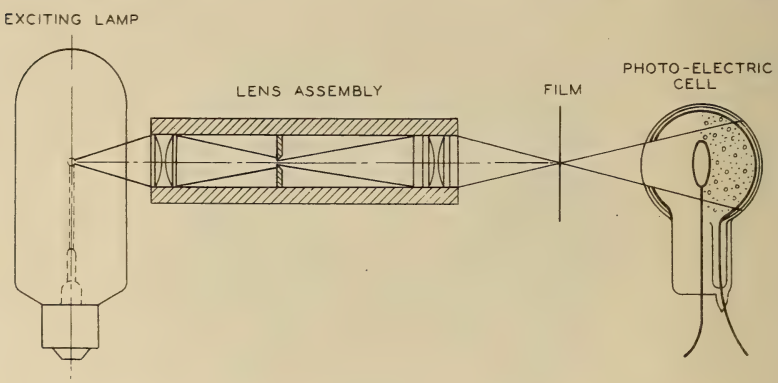

FIGURE 7.

imperfections of the driving gears. The uniformity of rotation of the sprocket is measured by a stroboscope method similar to that previously described for use with the disc reproducing unit turntable.

It is also essential to have the sound sprocket run very true and its teeth spaced very uniformly. If this sprocket runs out of true more than 0.0006 inch and if the error in spacing of the teeth exceeds 0.0008 inch, the velocity of the film as it passes the sound light beam is affected to an extent that would cause noticeable flutter of the reproduced sound. For this reason the sound sprockets are manufactured and assembled so that they come within these tolerances.

Optical System

The optical system used in the film reproducing sound unit to pick up the sound from the film is shown on Figure 7.

The lamp filament which is a horizontal coil produces a concentrated line source of light of high intensity. This filament is energized with a current of about 4 amperes at 8 volts. The light from this filament is focused by means of a condensing lens so as to illuminate a narrow opening in the lens assembly 0.0015 inch wide by 3/16 inch long as brightly as possible. An image of this opening is then focused on the film by means of a high quality objective lens with an optical reduction of $1\frac{1}{2}$: 1 so that a beam of high intensity light 0.001 inch wide passes through the sound track. The length of the light beam is masked to 0.080 inch by an opening in the aperture plate over which the film travels.

The lens assembly is mounted in a tube which is carried on

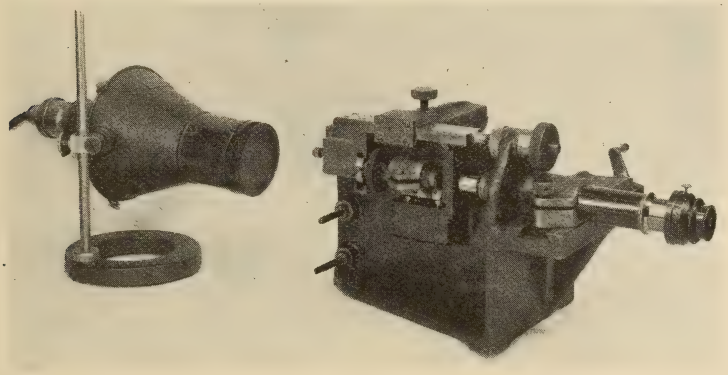

FIGURE 8.

a frame that also mounts an aperture plate with which the emulsion side of the film is in contact when passing through the machine. The lens tube is adjusted in this holder so that an illuminated image of its opening is focused on the film contact surface of the aperture plate to the required width of 0.001 inch. Adjustment of the lens tube to obtain this focus is done by means of a microscope fixture with micrometer adjustments so that the light beam is properly focused and lined up parallel to the striations on the sound film to within 0.0001 inch over a length of 0.080 inch. This fixture is shown on Figure No. 8.

The exciting lamp is adjustable in all directions so as to properly illuminate the opening in the lens tube. A window in the side of the lens tube between the condensing lens and the opening permits of observing the position of the image of the lamp filament

as the lamp is being adjusted. A spare exciting lamp is mounted in a bracket and prefocused so that it is available for immediate replacement in case a lamp burns out. With this prefocusing arrangement, burnt out or otherwise defective lamps may be quickly replaced during the showing of a picture.

Sound Gate

It is very essential that the pressure pad on the sound gate be in contact with the film while the machine is in operation. Unless this gate is closed the film can move out of its proper position and therefore the light will not be properly focused on the sound track. This condition would very seriously affect the reproduction of sound. To prevent this happening the sound gate operating mechanism is so arranged that if the sound gate is left open a latch prevents the door on the sound compartment from being closed thereby calling the operator's attention to this condition when he attempts to close the sound compartment door.

Photo-electric Cell and Amplifier

The sound film used in this machine may be either the varying-density constant-width type or the constant-density variable-width type. The sound track can be considered as a valve controlling the intensity of light passing through the film. After passing through the film this variable-intensity light then enters a photo-electric cell.

The characteristic of the photo-electric cell is such that when it is polarized by a proper voltage and used within proper limits, the current through it is directly proportional to the light that enters it.

A vacuum tube amplifier which serves both to increase the energy level of the photo-electric cell and to make that energy available across a low impedance circuit is mounted on the machine below the photo-electric cell compartment. The amplifier compartment also contains a switching system by means of which the output of either a disc or film record can be switched into the theater amplifier and loud speaker units.

As previously pointed out there is some vibration present in the machine. If these vibrations are permitted to vibrate the vacuum tubes in the amplifier a very objectionable noise would be set up in the reproducing system. To prevent this the vacuum tubes are

mounted on a spring suspended platform. The mass of this platform and the resiliency of the suspension springs are so proportioned as to absorb practically all these vibrations before they are transmitted to the tubes.

Film Chute and Hold-back Sprocket

The film after it leaves the sound film reproducing unit described above passes through a chute and over a sprocket, the purpose of which is to hold back the film against the drag of the film rewinding or take-up mechanism. The film between the sound sprocket and this take-up sprocket is kept loose with about a two hole loop so that any irregular action in the hold-back sprocket drive will not affect the velocity of the film as it passes through the sound pick-up light. The door on the film chute that contains this section of film is arranged so that it cannot be left open when either the door on the sound unit or on the film magazine compartment is closed.

Brake, Guards, etc.

Due to the addition of several flywheels and various mechanisms to the regular projector mechanism this machine normally takes a much longer time to come to rest after the driving force has been cut off than regular projectors. This condition is very objectionable as in the case of breakage of film or trouble of a similar nature it is very desirable to be able to stop the machine very quickly. To provide for a quick stop a brake has been added that acts on the motor flywheel. This brake, which is foot operated, is so arranged that when a foot pedal is depressed it first cuts off the power to the motor and immediately applies the brake shoe to the motor flywheel. The brake shoe is kept in contact with the flywheel under the action of a spring so as to prevent the possibility of too suddenly stopping the machine and damaging some mechanism. The brake shoe spring is adjustable by means of a screw so that the braking effort can be made such as to stop the machine in from 3 to 20 seconds. In starting the machine the foot pedal is lifted. This operation first removes the brake shoe from contact with the motor flywheel and then closes a switch in the motor circuit.

Suitable guards are provided around all revolving mechanisms such as turntables, flywheels, gears and shafts to prevent the operator coming in contact with these mechanisms.

The base of the machine is mounted on four legs which are adjustable in height so as to permit of adjusting the height of the

projector head over a range of 10 inches. The lower end of these legs are equipped with a ball and socket type of foot, one part of which is screwed on to the end of the leg and can be used to accurately level up the machine.

When projecting a picture from a sound film it is of course necessary that a projection of the sound track does not appear on the screen. To prevent this happening the picture aperture in the projector head has been provided with a sliding piece that can be moved forward to mask off the sound track when projecting sound film and moved back to permit projecting the full width of a regular motion picture.

DISCUSSION

MR. CRABTREE: Will you give us some idea as to the relative efficiencies of various types of mechanical filters such as a flywheel, a belt drive, cutting plate, a combination of the two, and so on? What can you recommend for laboratory use, assuming that we can't purchase a mechanical filter of this type from you?

MR. PFANNENSTIEHL: A belt and a flywheel is a fairly satisfactory mechanical filter, but in this machine where we must have synchronism, we can't use a belt. We have described two mechanical filters—one the friction damped type and the other hydraulic-damped and both are effective. There are advantages in the hydraulic type as the damping means is not subject to wear and change. The hydraulic type is somewhat more complex and expensive to make, however.

MR. CRABTREE: Are there any types of filters other than those which you have described?

MR. PFANNENSTIEHL: I don't know of any.

MR. GILMAN: Do you know anything about a turret or base to permit pushing the picture to the side when the sound film is on?

MR. PFANNENSTIEHL: We are working on this.

MR. GILMAN: Do you know of one used today?

MR. PFANNENSTIEHL: You mean to permit changing from silent to sound film and keep the picture the same size on the screen? That is being worked on by the laboratory but is not in commercial production.

MR. GILMAN: In Chicago they are putting a base on the top which permits this correction.

MR. PFANNENSTIEHL: I have heard of such devices but haven't seen them.

MR. CRABTREE: Another scheme is to mask off at the screen.

MR. PFANNENSTIEHL: I have seen that done, but we feel that it is better to keep the frame line the same on the screen for both sound and silent pictures.

MR. EDWARDS: There are one or two points about this projector base that I think are worthy of attention. The lower magazine door catch is one and a quarter inches from the tone arm. The spring on the catch is of such design that in order to open the door you must throw the spring in the direction of the tone arm and often it is thrown off, causing the needle to be displaced on the record.

MR. PFANNENSTIEHL: We have a guard that mounts on the magazine and prevents the operator's hand from coming in contact with the tone arm. This can be added to the present machines.

MR. EDWARDS: We also have a high intensity lamp used very much now in which lubrication is carried out by means of oil cups, and drops trickle on the record. Couldn't a guard be interposed to prevent oil and molten copper dropping through the bottom of the lamphouse?

MR. PFANNENSTIEHL: It is possible to put a guard over the turntable but we haven't anything of that sort yet.

MR. EDWARDS: You have a straight rod at the back and under certain projection inclinations there is produced appreciable vibration in the rod. The rod is about one inch in diameter or less. Couldn't that be prevented?

In the retaining weight for the records—the action of the spring with the shaped cam in the record—when the spring is exercising its full force, it raises the weight instead of holding it on.

MR. PFANNENSTIEHL: That isn't our experience. The particular one you mention must be defective. It is intended to clamp the record when the trigger is released.

MR. EDWARDS: When the trigger is released the weight is lifted. These are minor things, however.

MR. PFANNENSTIEHLS In that case the clamp is not as it should be.

MR. EDWARDS: That's it; when you get the small things right it will be better.

MR. LAMBERT: There is danger of using the brake too freely from the standpoint of the film and the machine. If you stop too suddenly, the fiber drive gear is liable to be stripped and you are liable to tear the perforations of the film. It should be used only for emergencies and not to stop the machine in practice.

SCORING, SYNCHRONIZING, AND RE-RECORDING SOUND PICTURES

K. F. Morgan*

MOTION picture engineers will understand better perhaps than electrical engineers the necessity for what has been termed "dubbing." The entire realm of trick photography and duping as a necessary adjunct to editing of the silent motion picture now has its counterpart in sound production in this process. Dubbing may be subdivided and classified as follows:

(1) "Scoring," or adding music to a picture that may or may not already have dialogue or sound;

(2) "Synchronizing," or adding new sound effects or dialogue in synchronism with a picture which has previously been photographed with or without sound.

(3) "Re-recording," or transferring a film or disc record to a new film or disc record by the electrical process originally used.

Thus the art of dubbing may be simply making a sound record with the microphone to match a picture, it may be the combining of new sound picked up by the microphone with one or more sound records already made, it may be the combining of sound records only, or it may be simply re-recording one sound record. The last mentioned has three principal purposes: First, to make a new master record; second, to transfer a record from film to disc or vice versa; and third, to correct volume variations and other defects.

Probably ninety per cent of all the world's present day machinery and electrical apparatus for adding sound to the silent drama has been installed and placed in operation in less than a year. While this tremendous demand for the manufacture and installation of equipment, together with certain contemporary modifications and developments found necessary in the field, was being met, it was natural that no great amount of thought was given to what might be considered a secondary adjunct, namely, re-recording or combining sounds for the final editing of a picture; consequently, this demand, almost as urgent as the first, presented itself when the first few productions were ready for editing, and while the recording installation work was at its height.

* Electrical Research Products, Inc., Hollywood, Calif.

Plans were under consideration, it is true, providing facilities for these processes at an early date, but it is doubtful whether or not anyone anticipated the variety of problems that would present themselves in adapting sound production to all the "tricks" of the motion picture art.

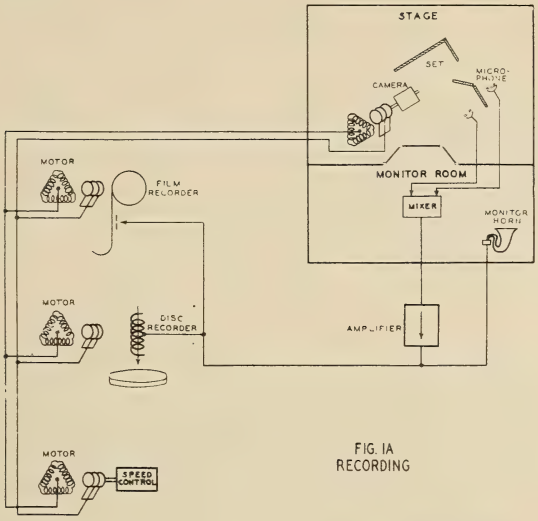

FIG. IA
RECORDING

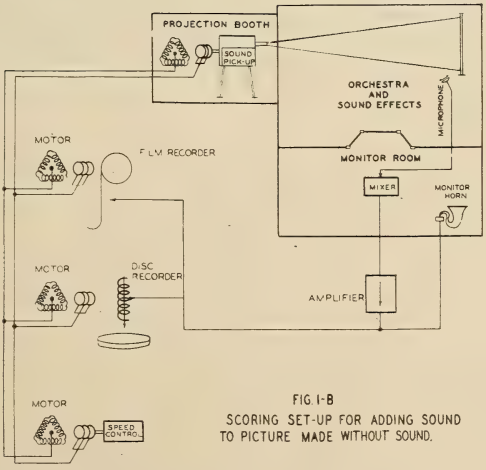

FIG. I-B
SCORING SET-UP FOR ADDING SOUND TO PICTURE MADE WITHOUT SOUND.

The first synchronized talking pictures were short Vitaphone subjects and Movietone news reels. In either case, the cutting and editing was fairly simple, each take being one scene complete in

itself. About the same time, due to the demand for "sound" pictures, there were those with electrical sound effects manually operated at each performance, not being mechanically synchronized with the picture. Then came the practice of making records of sound effects or dialogue to match the silent sequences. Schematic drawings indicating the general methods used in recording, scoring and synchronizing, are shown on Figure 1, A, B and C. A close similarity between these processes will be noted from an inspection of the figures. In synchronizing and scoring a projector and screen replace the camera and stage.

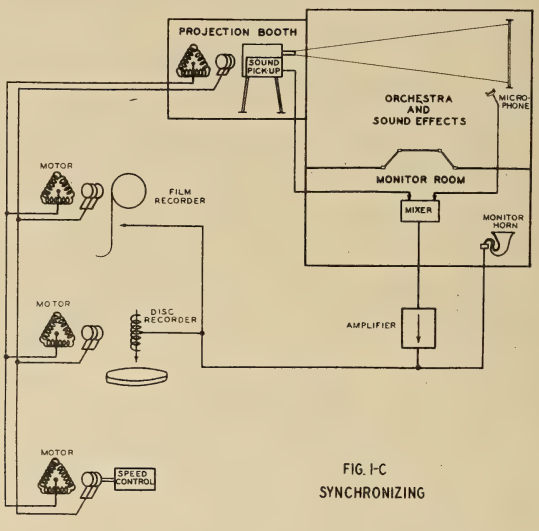

FIG. I-C
SYNCHRONIZING

The introduction of synchronized sound and dialogue into pictures of feature length presented the problem of sound cutting. When the sound was recorded on film the problem was fairly simple since the sound track could be cut in the same manner as the picture. With the original recording on disc, the cutting became a rather involved mechanical as well as electrical process since the scenes as recorded had no definite chronological relation to the final product. This introduced the first necessity for re-recording sound. The re-recording method required the use of a number of disc reproducing machines so connected as to operate in synchronism with a recorder. The sequence and duration of the various takes on several original records having been determined, a cue sheet was prepared.

The application of the cue sheet involved a revolution count, which insured the cutting in and out portions of these sound records in the sequence of the cut picture. This process required an operator at each turntable, as well as personnel for counting revolutions and cueing. Subsequently, the counting was simplified by the use of a record which actually reproduced the revolution count. Finally a machine was developed which rendered the process automatic.

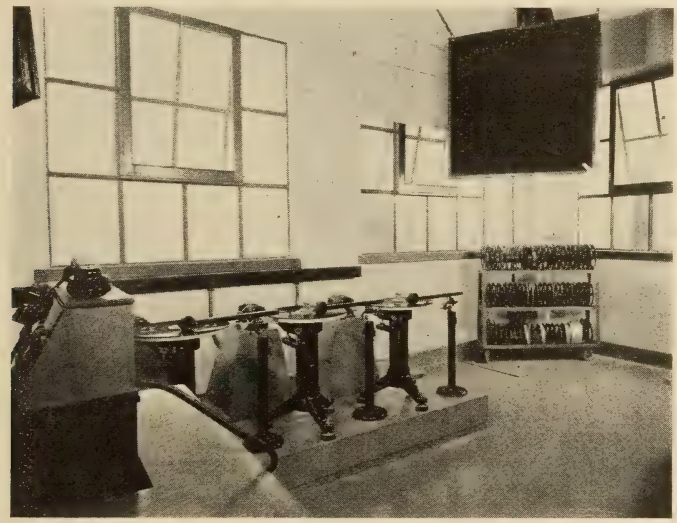

FIGURE 2.

Early sound pictures, due to recording and production problems, were part talking, with the silent scenes scored, and sound effects added. The latter was accomplished by projecting the picture upon a screen on the recording stage where the desired sounds could be produced. If the projection and recording machines were interlocked by a synchronous motor system, the resultant sound record would be in synchronism with the picture. A schematic drawing indicating such a set-up is shown on Figure 1, C. Synchronizing and scoring are now extensively employed. The results are often more satisfactory when the original take involves dialogue only, than when all the incidental sound effects are recorded at that time. This is true for two reasons: First, many exterior shots must be built up on the sound stage and it is not possible to accurately stimulate the actual condition of accompanying noise. This applies particularly

to street scenes and scenes involving water or rain effects. Second, revolver shots, explosions, or other violent noises will often sound unnatural or have too severe an action on the recording medium to be included in the original take. In these cases the scene is taken minus the sound effects and these effects are synchronized after the picture is completed.

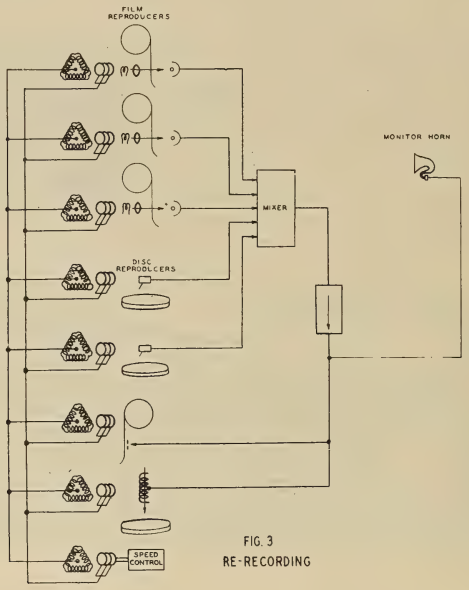

FIG. 3
RE-RECORDING

There were early ideas of accumulating "libraries" of recorded sound effects which could be introduced into a picture where needed. In order to add sounds (original or recorded) to those of a picture already produced, it is required that the original be re-recorded. A schematic drawing of a re-recording system is shown on Figure 3. This was the function demanded in the studios just as it seemed that the production of "all talking" pictures was safely under way. Several important pictures had been scheduled for release, and were nearing completion when it was found necessary to perform all of the above mentioned processes before release could be made.

As stated above, the need for dubbing was anticipated. In fact, it was considered as a simple application of already developed processes. This in a measure was correct, but even the combining of known processes presented detailed problems, which required a cer-

tain amount of engineering. When the sound currents are obtained from a disc or film record rather than from a microphone direct, the pickup must be made to reproduce the original sound currents with the utmost fidelity. Extraneous noises must not be introduced in this process of re-recording. These problems, together with a

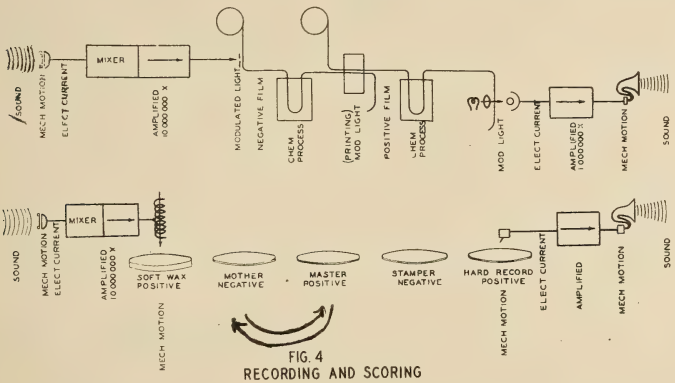

FIG. 4
RECORDING AND SCORING

somewhat different circuit layout, constitute a part of dubbing which will be considered later in more detail.

Fig. 4 shows the various steps of recording and re-recording sound. These drawings indicate the rather unusual transformation which takes place during the interval from the picking up of the original sounds to their restoration in the theatre. Referring to

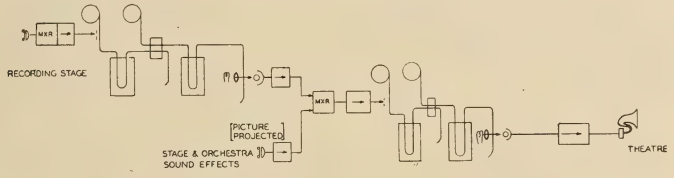

FIG. 5
SYNCHRONIZING.

the simplest of the processes, namely, recording and scoring on film, it is of considerable interest to trace these changes. Beginning as sound waves, mechanical motion is imparted to the diaphragm of the condenser transmitter. This mechanical motion is in turn translated into a minute electric current. After being amplified the power of this current modulates a light to which film is exposed. The resultant latent image is treated chemically and when developed, again

modulates a light to produce the positive. After development this positive, when run thru a projector, modulates a beam of light, thereby controlling a minute electric current. After amplification the resultant power is sufficient to impart mechanical motion to a loud speaker diaphragm, thereby producing a very close approximation to the original sound. Beginning as sound, fourteen changes of condition must be passed thru before the sound is re-formed. The same number of changes occur in recording on disc.*

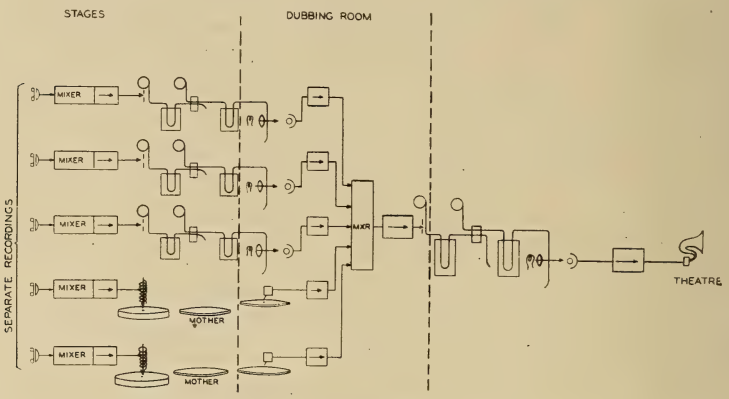

FIG. 6
RE-RECORDING.

When sound is re-recorded there is no intermediate sound step, the energy representing the sound being dealt with in the electrical

* The change in condition in the recording process are as follows:

	Film		*Disc*
0	Sound	0	Sound
1	Mech. Motion	1	Mech. Motion
2	Small Current	2	Small Current
3	Large Current	3	Large Current
4	Mod. Light	4	Mech. Motion
5	Latent Image	5	Soft Wax
6	Metallic Image	6	Master
7	Mod. Light	7	Mother
8	Latent Image	8	Stamper
9	Metallic Image	9	Hard Wax
10	Mod. Light	10	Mech. Motion
11	Small Current	11	Small Current
12	Large Current	12	Large Current
13	Mech. Motion	13	Mech. Motion
14	Sound	14	Sound

state. From the standpoint of the changes involved, synchronizing and re-recording are similar, as shown on Figures 5 and 6. These latter processes involve 25 changes of condition when re-recording from film to film and 22 changes of condition from disc to disc. **

It was found desirable to arrange the amplifiers in the reproducing circuit so as to reduce mechanical vibration to a minimum. Special amplifiers were built to meet the requirements of re-recording work. (Fig. 7)

It was also necessary to carefully guard against noise being introduced by circulating currents and foreign potentials.

The process of recording is such that there is a tendency for the low frequencies to be relatively over emphasized. This tendency is not objectionable in the original recording, but becomes undesirable in successive recordings, since it is cumulative. Fortunately, it is possible to do almost anything desired with the frequency re-

** The changes in condition in the re-recording process are as follows:

Film		*Disc*	
0	Sound	0	Sound
1	Mech. Motion	1	Mech. Motion
2	Small Current	2	Small Current
3	Large Current	3	Large Current
4	Mod. Light	4	Mech. Motion
5	Latent Image	5	Soft Wax
6	Metallic Image	6	Mother
7	Mod. Light	7	Hard Wax
8	Latent Image	8	Small Current
9	Metallic Image	9	Large Current
10	Mod. Light	10	Mixing
11	Small Current	11	Large Current
12	Large Current	12	Mech. Motion
13	Mixing	13	Soft Wax
14	Large Current	14	Master
15	Mod. Light	15	Mother
16	Latent Image	16	Stamper
17	Metallic Image	17	Hard
18	Mod. Light	18	Mech. Motion
19	Latent Image	19	Small Current
20	Metallic Image	20	Large Current
21	Mod. Light	21	Mech. Motion
22	Small Current	22	Sound
23	Large Current		
24	Mech. Motion		
25	Sound		

sponse of the electrical portion of the system, hence it was only necessary to design an equalizer to counteract the over emphasis of the low frequencies. Due to the variation of different records, the equalizer was made adjustable.

Photographs illustrating dubbed sound tracks are given on Figure 9. The process of dubbing two separate records together is illustrated by track 4, which was produced by combining tracks 3 and 5. The original tracks, 3 and 5, are single frequencies. A re-recording composed of speech and music is illustrated in track

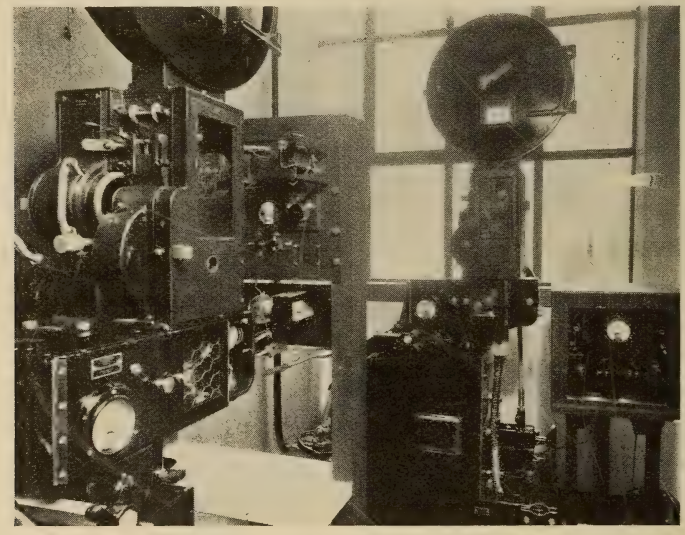

FIGURE 7.

7, being the combination of tracks 6 and 8. From an analysis of track 7, its component parts could be shown to consist of tracks 6 and 8, although with such complex sounds it is not as apparent to the eye as the dubbed track composed of two different sine waves illustrated in track 4. Track number 1 has been combined from two separate records of music and dialogue. This record was then re-recorded four times, track number 2 in the picture being the fifth successive re-recording. It will be noticed that successive re-recordings tend to diminish resolution, which of course affects quality. When the fifth re-recording is projected and the sound compared with the original recording, the quality is not greatly impaired.

Such an experiment as this requires the utmost care and supervision, but indicates the possibilities of re-recording. In general, although each re-recording actually introduces a slight loss in quality, in some cases defects in recording, such as "tubbiness" may be artificially improved.

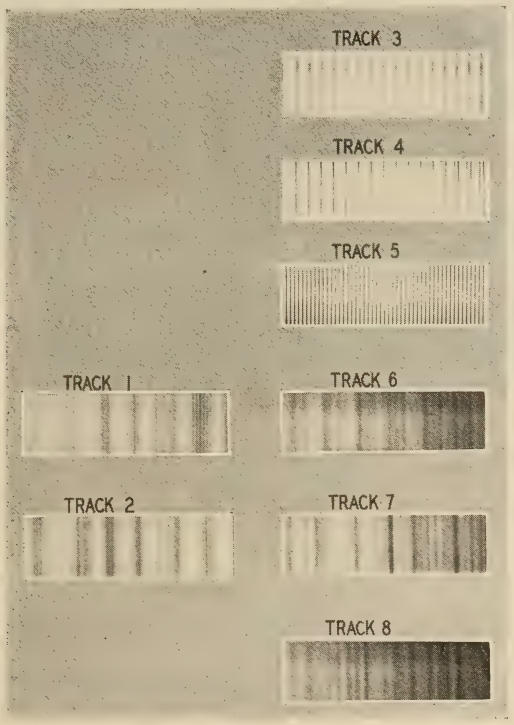

FIGURE 9.

The processes outlined are in a stage of development; consequently the space allotted to this equipment and the type of layouts in the various studios are by no means uniform. It may readily be appreciated that in scoring a picture, the standard recording channel can be used as the pickup by microphone, as in regular picture production, and the mixing is essentially the same. This also holds for the synchronizing operation such as adding sound effects to a completed picture. In the case of re-recording, it is desirable to adjust the volume of the output of the disc and film

reproducers so that it may readily be mixed with musical accompaniment and sequences, and thence put through the regular channel. Due to the threefold function of dubbing, it is, of course, desirable

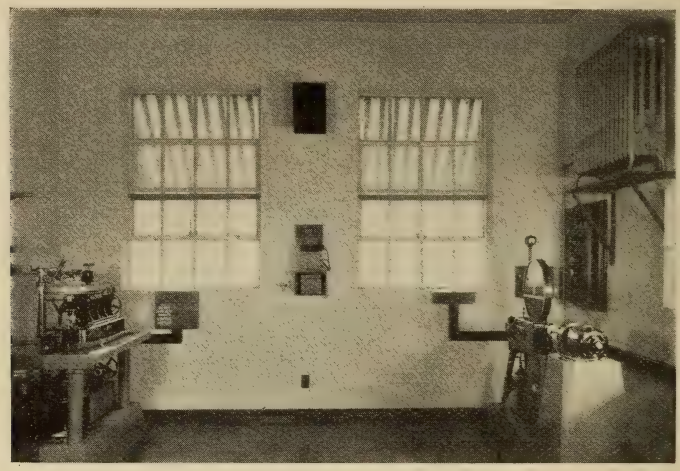

FIGURE 10.

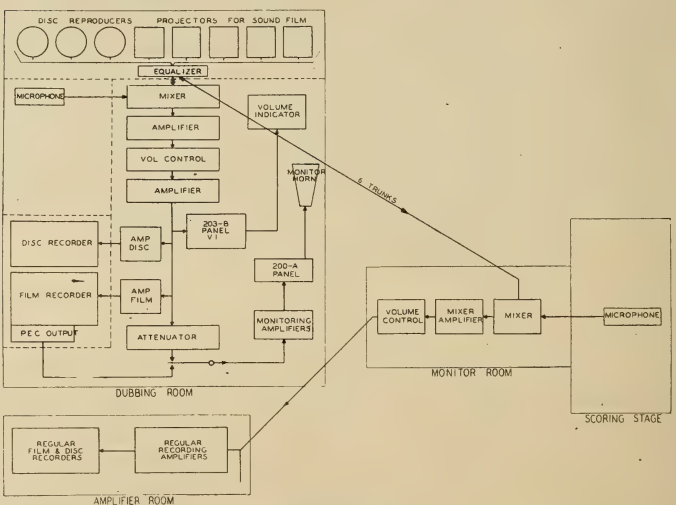

FIGURE 11.

to provide for utmost flexibility in the wiring scheme, as indicated to some extent in Figure 11. This, of course, applies to the signaling and motor system, as well as the transmission circuits.

Each studio is providing room for dubbing equipment consisting of film and disc reproducing apparatus, a mixer and monitoring facilities. For suitable monitoring, it is necessary to surround the film reproducers, which are modified projectors, in sound-proof booths to eliminate noise from this source. In some cases one of these projectors is also arranged to throw the picture on a small screen in order to cue sound effects taken from stock records. One studio is enclosing a section of the dubbing room in sound-proof walls for microphone pickup as shown on Figure 12.

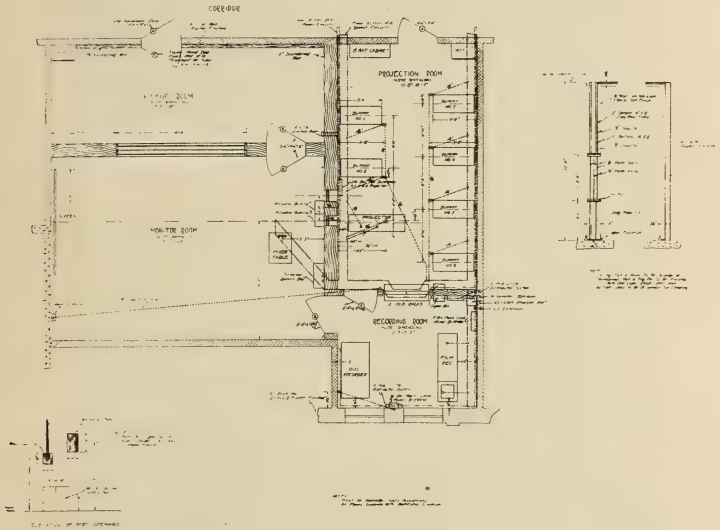

FIGURE 12.

For re-recording or synchronizing, the mixing is done in the dubbing room and the output of the mixer may be connected to any regular recording channel. (Figure 13—Recording Amplifier Rack, Front View.) This is being done in many cases and is only open to the objection that it ties up a regular channel which may be under a heavy production schedule. Where this is to be avoided, a separate complete recording channel is provided in the dubbing room. This usually consists of the standard amplifier equipment with one disc and one film recorder. Another advantage is that, with all the equipment thus concentrated in the dubbing room, a smaller personnel is required for the re-recording operation. (Figure 14—Recording Amp. Rack, Back View.)

For scoring purposes, a sound-proof stage of sufficient size to accommodate a large orchestra and a variety of sound effect apparatus, and provided with the usual recording stage monitor and control equipment, is used. (Figure 15—Scoring Stage.)

It is, of course, necessary to provide for the synchronous projection, on this stage, of the picture to be scored. (Figure 16—Floor Plan of Scoring Stage.)

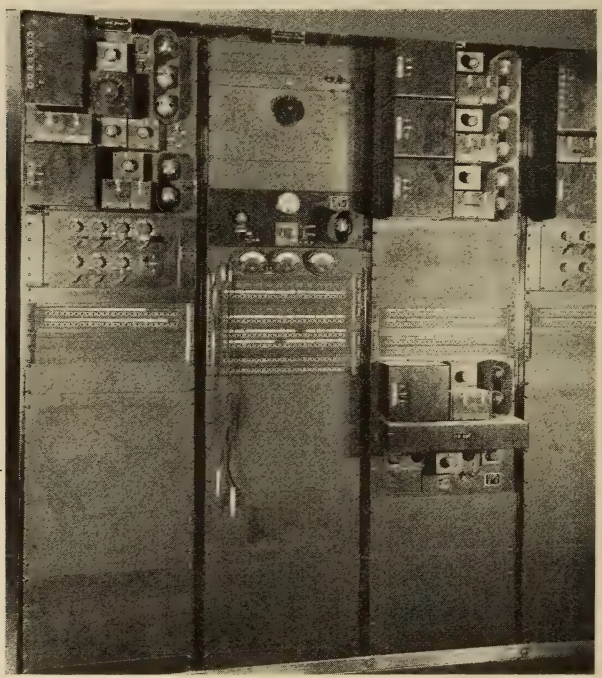

FIGURE 13.

Figure 16 shows the approximate floor plan arrangements of one installation in which it may be noted that the scoring stage is also equipped with an organ. The space designated as "scoring rooms" is arranged to project pictures and sound, and is used in planning the scoring and also for reviewing scored pictures.

The scoring stage is usually connected to a recording channel consisting of regular amplifiers and recorders. For introducing musical accompaniment to pictures with dialogue, the functions of the dubbing room are combined with those of the scoring stage as

is indicated in Figure 11. As may be seen, the output of the film or disc reproducer is wired directly to the scoring stage mixer where it is combined with scoring or other sound effects as desired. This arrangement of the dubbing layout permits independent re-recording operations to be carried on simultaneously with the scoring of pictures having dialogue.

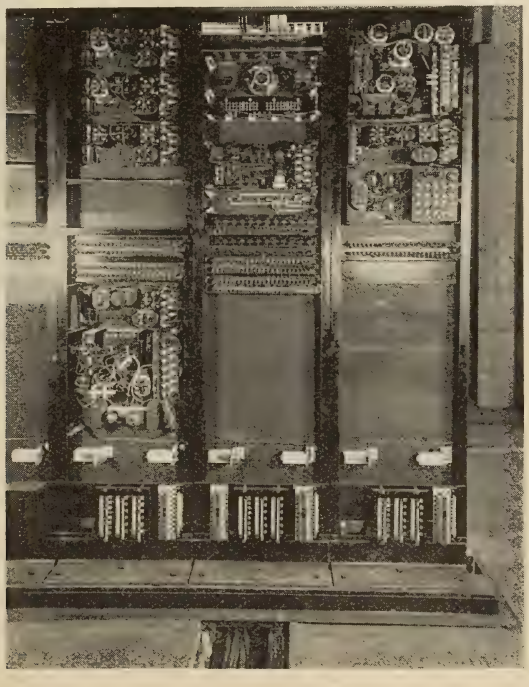

FIGURE 14.

The process of synchronizing involves the development of a careful technique. At one studio recently it was necessary to synchronize sound effects of an elaborate nature with one reel of picture containing part dialogue and outdoor scenes taken without sound. Several microphones were used and the noises picked up included three automobiles, starting, stopping, reversing, and involved in a chase; people walking and running over a gravel walk; rain, thunder, and miscellaneous effects such as footsteps on stairs, opening and closing of doors and tooting of horns.

Needless to say, synchronization of such an involved nature

requires careful rehearsal and infinite patience. The finished product is well worth the effort, as the picture has a better entertainment value when the effect of realism is carried out.

FIGURE 15.

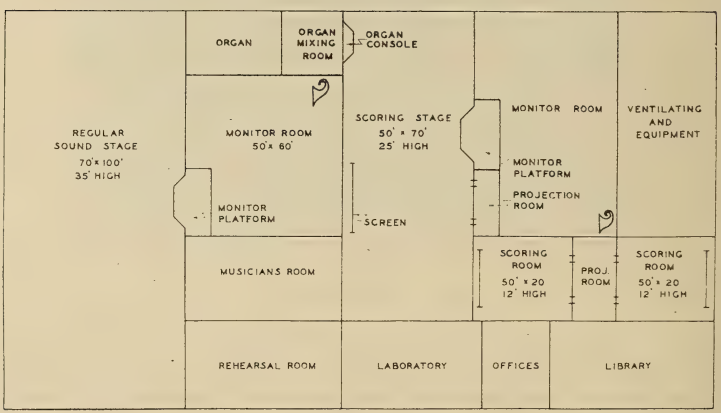

FIGURE 16.

The material and devices for adding sound in this manner are both novel and elaborate as well as numerous. One of these devices is shown in Figure 17. (Figure 17—Noise Machine.) This was constructed at one studio and simulates the noise made by a subway train pulling out of a station.

Scoring has become of utmost importance to the sound studios and in many cases large symphony orchestras consisting of the best talent obtainable, are employed. The musical director and composer must review the picture many times in order to write and arrange a score that harmonizes with the action and enhances the dramatic effect. Many theme songs destined to become popular are composed in the studio review rooms by members of the musical staff.

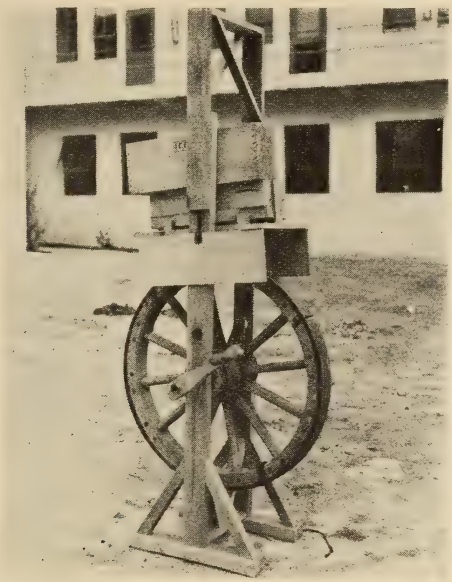

FIGURE 17.

In conclusion, the dubbing operation has been instrumental in supplying a unity and finesse as well as rhythm and continuity to the sound picture. There are some who believe that as the technique of sound recording is developed to a high degree, the need for dubbing will be diminished or even eliminated. However, dubbing has contributed largely to the success of recent sound pictures and the indications are that, in all probability, its application will expand with the development of the art. Many, therefore, believe that the dubbing process will continue to be an increasing factor in the success of sound pictures.

DISCUSSION

Mr. Coffman: I should like to emphasize as strongly as I can the tremendous importance to the industry of this matter of re-recording or "dubbing." As Mr. Morgan stated, it was not at first thought that re-recording would be necessary, and it was done with the idea of combining various sounds which, for some reason, could not be done at the time of original recording. It looks now as if actual production negatives will be "dub" negatives. There are many reasons for this: the films are recorded at different times, and it is almost impossible to hold the transmission of the negatives to the same points, to hold the gammas, and get negatives printable with the ordinary facilities on ordinary machines, but it is possible to make compensations for this in making the print, and if you cut the sound print in the proper way and make a dub from this, you have a continuous film in which the volume levels have been adjusted, and the transmission of the entire piece is the same; it can be printed on the same printer light and other effects added which it was impossible to record originally. That means it will not be so necessary to record everything at the level which you propose to use in the final production negative. An effort has been made in the past to record something, at the low level, and this gives trouble sometimes. I believe in the next year things will be recorded at the best level for recording and adjustment made by the dubbing. Dubbing is acoustic cutting, and everyone of you is familiar with the effect of editing on the dramatic effect of the picture. The dubbing process has a great deal more elasticity than the editor's scissors ever had, and things can be done by acoustic cutting which were never possible by mere pictorial cutting. I should like to make a plea to everybody in that direction and see if they don't come to the conclusion that the dubbing will be as important as the original when it comes to the dramatic effects that make really great pictures.

Mr. Crabtree: To what extent is multiple printing from several negatives on to one positive employed instead of dubbing before the microphone?

Mr. Morgan: None whatsoever at Hollywood. We have made experiments on the side but nothing has been done on a production basis.

Mr. Gilman: I want to say that I think "dubbing" sounds to the outside like "duping," and a more appropriate name should

be used than "dubbing." It looks as though we were making up something and using something else; we are really not doing that.

MR. LE GRANDE: It might be interesting to members and guests to know that we have already duped dialogue and music on film in a printing machine very successfully.

MR. MORGAN: What was that; superimposed or split sound track?

MR. LE GRANDE: It wasn't split; it was superimposition.

MR. COFFMAN: I want to emphasize again that careful distinction must be made between "duping" and "dubbing." Duping is the reproduction of a negative by a photographic process, and dubbing is totally different; it is a paradox of the original itself. As I think Mr. Morgan demonstrated, it is not necessary to sacrifice quality appreciably in the matter of making re-recording. I believe that as the experiments develop further, as they undoubtedly will, you may be able to improve the quality of the original because you can insert sounds and get away from the idea presented to the motion picture mind by the term "dupe."

DR. HICKMAN: Has anything been done to form a library of sounds? There are times when certain sounds are necessary without the sources of the sound appearing in the visual presentation. For instance, the trained animals which have to be carried around for farm yard scenes might often be done without, and the cries assembled separately in the laboratory.

MR. MORGAN: What we do is to go to the farm and record the natural sound. The processes connected with re-recording are too new for much of a library to be built up at this time, but the ambition is to have all sorts of sounds collected in a Sound library so that any required sound may be introduced into a picture in the final editing.

PUBLIC ANNOUNCEMENT AND REINFORCEMENT SYSTEMS FOR THEATRES

J. B. Irwin*

WITH the introduction into theatres of equipment for reproducing sound in conjunction with the presentation of motion pictures, it was evident that the sound projector system might also be used for other purposes. Some of these special uses were referred to in Part No. 1 of a paper by Scriven and Santee, entitled "Western Electric Sound Projector Systems For Use in Motion Picture Theatres," which was presented before this Society at Lake Placid last September. It is the purpose of this paper to outline these special applications in more detail and to describe briefly the apparatus which is furnished with Western Electric Sound Projector Systems for adapting them to these special uses.

The first of these special applications and, perhaps, the simplest one, is the use of the system for announcing purposes. With the addition of a microphone, a control box, and a switching panel, the theatre manager is equipped to make announcements to the audience during intermissions or between pictures. This attachment may be used to announce details of future programs and to supplement picture advertising of forthcoming attractions; to acquaint the audience with new developments in the motion picture industry or in the policy of the theatre; to present news items of local interest, or for paging.

The microphone employed with this attachment is the familiar double button carbon microphone now widely used in radio broadcasting. It is mounted in a housing equipped with a cord and plug which fits into a jack in the control box. In addition to the jack, the control box contains a key and two signal lamps. The green signal lamp lights when the circuits are set up for announcing, and the red signal lamp lights when the announcer presses the key preparatory to making the announcement. This light is intended as a warning to the announcer that any sounds arising in the room will be transmitted to the audience. The microphone and control box, are located in the announcing room. This room is usually the

* Electrical Research Products, Inc., New York, N. Y.

Manager's office, although it may be any convenient location where the microphone is not in the field of the sound coming from the loud speakers. The switching panel previously mentioned is located in the booth on the rack which contains the amplifying equipment. It contains keys for switching from synchronous reproduction to either announcing or non-synchronous reproduction, together with signal lamps which show the type of reproduction for which the keys are set. A signal lamp also indicates to the operator when the announcer presses his key. This panel includes a repeating coil with which are associated the circuits for supplying current to the buttons of the microphone and the jacks into which may be inserted a plug connected to a meter for measuring these currents. A relay containing a pair of normally closed contacts which short circuit the output of the repeating coil is also mounted on this panel. It is operated by the key in the control box and is therefore under the control of the announcer as long as the key on the switching panel is in the "Announce" position. The amplifiers and loud speakers which complete the announcing system are those described in the paper previously referred to.

The change-over from synchronous reproduction to announcing is a very simple operation. When an announcement is to be given, the announcer notifies the projection room and inserts his microphone plug into the jack in the control box and waits for the "ready" signal. At the proper moment, the projectionist brings his fader to the "zero" position and throws the key on the switching panel to the "Announce" position, thus lighting the signal lamps which indicate both to himself and to the announcer that the system is set up for announcing. It may also be necessary for the projectionist to change the setting of the potentiometer on the amplifier in order to obtain the proper volume of sound in the theatre. The setting depends primarily on the announcer's voice and his position with respect to the microphone when announcing. The proper setting is determined before hand and if a change is necessary it is made before the key on the switching panel is thrown. When the announcer sees the green light on his control box he knows that the system is ready for his use. He presses his key, a visual indication appears on his control box, and on the switching panel in the booth, and he proceeds to make his announcements. The system is not operative for announcing purposes unless the announcer has his key in the proper position. As soon as the an-

nouncer releases his key the signal lamp on the switching panel in the booth goes out, the projectionist throws the key on the switching panel, resets the potentiometer on the amplifier (if necessary), and the system is again ready for synchronous reproduction. If a series of announcements is to be made it is necessary to have a prearranged schedule in order that the projectionist who hears the announcements through the monitoring loud speaker will not switch circuits before all announcements have been made.

The second special application of sound projector systems is their use for reinforcing the audible portions of stage presentations. Such a system is ordinarily used only in de luxe houses which put on elaborate stage presentations, or in houses where the acoustics are faulty. With the addition of microphones, special control equipment, and loud speakers, it is possible to reinforce sounds originating on the stage, in parts of the theatre where they were previously not clearly audible. The microphones are usually located in the footlight trough, although microphone outlets are also placed at convenient locations back stage. The special control equipment, shown in Fig. 1, consists of a number of panels mounted on a rack similar to the racks used for the amplifying equipment in sound projector systems. This rack assembly may be set up in any convenient location, preferably in view of the stage, and in, or adjacent to the

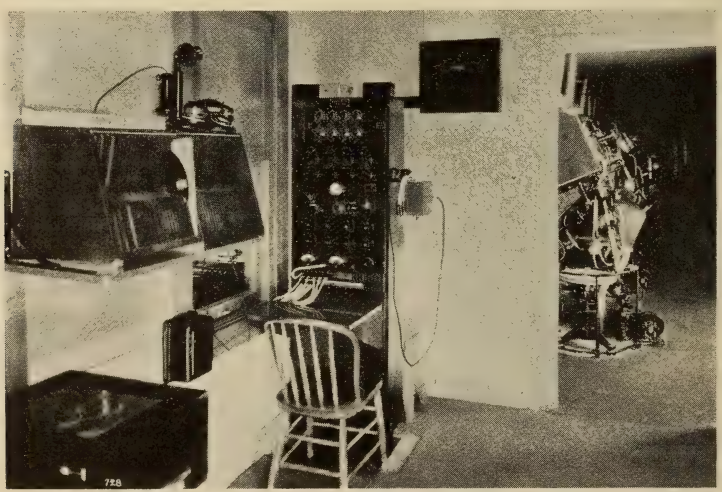

FIGURE 1. Typical Installation of Control Equipment for Sound Reinforcement.

motion picture booth. The panels which make up this equipment are as follows:

Miscellaneous equipment panel
2 Jack panels
2 Volume control panels
Volume indicator panel
Rheostat and key panel
Horn control panel

The microphone circuits from the stage terminate in jacks on one of the jack panels which provide for twenty stage circuits. By means of patching cords any one of these circuts may be connected to jacks on the second jack panel which, in turn, connect through an individual control channel to the main volume control circuit. There are eight of these individual control channels, each of which contain circuits for supplying current to the microphone, a means of regulating and measuring these currents, a key for connecting and disconnecting the output circuit, and a volume control potentiometer. The apparatus comprising these control channels are mounted on the miscellaneous equipment panel, the rheostat and key panel and one of the volume control panels. The circuits are so arranged that all of the control channels which are in use are connected to a common output circuit leading to the main volume control potentiometer on the second volume control panel. This latter panel also contains a signal lamp which indicates when the main amplifier circuits are set up for sound reinforcement operation.

In addition to the apparatus comprising this special control equipment, an amplifier and a switching panel are also required. The amplifier serves to compensate for the losses which are inherent in the special control circuits and also provides reserve amplification which may be used if the relative locations of the sound sources and microphones on the stage require it. The amplifier is of the same type as the first unit of the main amplifying system described in the paper previously referred to. Associated with it is a small panel containing a transformer which is connected between the output of this amplifier and the input of the first unit of the main amplifying system. The switching panel is used to switch the circuits at the input and output of the main amplifying system from synchronous reproduction to sound reinforcement. It contains a key for switching the circuits and two signal lamps which indicate the type of operation for which the key is set. The three panels

described above are mounted on the main amplifier racks in the booth, in order that switching may be under the control of the projectionist. Fig. 2 shows a typical layout of the circuits in block schematic form.

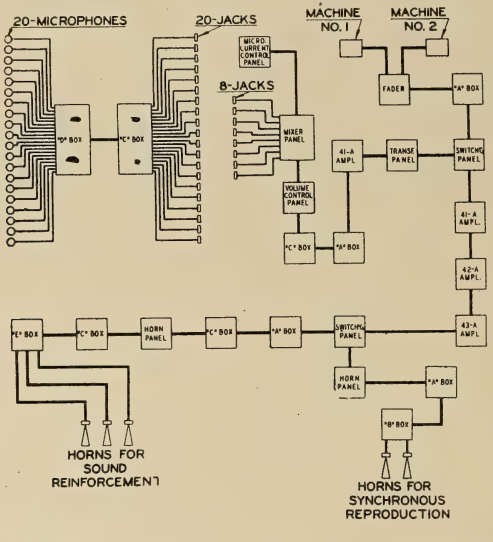

FIGURE 2. Typical Circuit Layout of Sound Projector System when used for Sound Reinforcement.

For reinforcement of stage programs it is essential to maintain the illusion that the sounds are coming from the stage, which requires that the loud speakers be mounted directly above the stage. Structural difficulties of the theatre sometimes prevent the use of the type of horn which would otherwise most satisfactorily serve conditions. Fortunately it is possible to obtain commendable results for reinforcement purposes from horns which have a less broad frequency response characteristic than would be a requisite where the system is used for sound reproduction in a talking motion picture system. The type of horn most commonly used is a folded exponential horn having an air column approximately 6 feet in length. Where space permits, the type of horn commonly in use for talking pictures, is, of course, employed, the horn being fitted either with a moving coil type of receiver or a balanced armature type.

The most common location for the loud speakers is in the proscenium arch immediately over the center of the stage and as near

the stage opening as possible. When placed in this position, they are usually located behind a decorated grill of such construction that the emission of sound is not restricted. The location of the horns is a very important consideration because failure to place them properly may entirely destroy the illusion that the reinforced sounds are coming from the stage. In existing theatres it is often impracticable to place the horns in the proper position due to the lack of available space where the horns may be concealed, or to the expense involved in altering the construction of the arch to provide the necessary space. This difficulty has been overcome in some instances by using an ornamental fixture which is designed to fit in with the architecture of the theatre and which is suspended from the ceiling. In new theatres this phase of the problem is given consideration and the architect works out a scheme which fits in with his plans. The number and relative positions of the loud speakers depend on the size, shape, and acoustic properties of the theatre. Each loud speaker (or group of loud speakers) is connected electrically to a separate position on the horn control panel which is a part of the special control equipment previously referred to. This panel contains an auto-transformer, the taps on which are paralleled to corresponding studs on eight dial switches, one for each of the horn circuits. The dial switches are used to adjust the relative volume from each of the loud speakers (or groups of loud speakers) and to maintain the proper impedance relation between the output circuit of the amplifier and the horn load, in order that the system may operate at maximum efficiency. In parallel with the input to this panel are connected the terminals of the volume indicator panel which is also a part of the special control equipment. This panel contains a galvanometer by means of which the operator obtains an indication of the power being delivered by the amplifier to the loud speakers.

For the operation of the system an operator is required at the control rack. Before the program starts he must see that the proper microphones are connected through to control channels and measure and adjust the currents in each. He must also check the adjustment of the volume indicator and the dial settings on the horn panel. The projectionist in the motion picture booth sees that the auxiliary amplifier is in an operative condition and at a pre-arranged point in the program throws the key on the switching panel, transmitting a signal to the operator that the circuits are under his control. The

operator follows the program by vision where he is in view of the stage, by listening to his monitoring loud speaker through which means he determines the settings of the individual volume controls, and by watching the volume indicator which assists him in regulating the main volume control. A shelf is provided on the control rack, just underneath the volume control panels, which serves as an arm rest for the operator. This is a desirable provision since the operator is adjusting some of the controls almost continuously. The operator occupies a very important position and probably contributes more than any other single factor to the success or failure of the results obtained from the use of the system. For this reason the program should always be rehearsed often enough for the operator to become thoroughly familiar with it. When the stage program is completed the projectionist throws the key on the switching panel to its original position which operation sets the equipment for synchronous reproduction.

The third application which is very closely allied to that outlined above is the use of the system for rehearsal purposes. When rehearsing stage presentations the director is usually seated near the front of the orchestra, from which position he gives instructions to the stage manager, to the men on the spotlight bridges back stage, and in the booth. It is often difficult for all parties concerned to hear these instructions, a condition which results in a great deal of confusion and delay. When a sound projector system is used for rehearsal purposes the director is furnished with a microphone connected through the system described above, to loud speakers placed near the positions occupied by the men who are to carry out the director's instructions. An arrangement such as this enables the director to give instructions to all of the personnel concerned without moving from his seat, and rehearsals are conducted more smoothly and without loss of time. It is also possible with a slight modification in equipment and circuit arrangement to provide facilities whereby any one of the men may answer questions asked by the director during the progress of the rehearsal.

SERVICING SOUND PICTURE PROJECTION EQUIPMENT IN THEATRES

Coke Flannagan*

THE problems met in installing sound picture projection equipment in theatres have been covered in a previous paper presented before this society. Upon completion of a theatre installation the question of maintenance or service comes to the fore. As in other industries, an up-to-date service policy contemplates the maintenance by periodical inspection of all parts of the system in the best possible condition. Most troubles are, through the intelligent application of the service policy, detected and remedied before becoming sufficiently advanced to seriously effect reproduction or result in a shut down.

In a high quality reproducing system there are a large number of possible causes of deterioration of output. In fact, most troubles effect quality to a certain degree depending upon their location. Fortunately, however, the apparatus has reached a state of development that practically precludes the likelihood of trouble in the strategically important portions.

Notwithstanding these advances there remain in this as well as in all other apparatus certain potential sources of trouble, the recognition of which requires training both theoretical and practical. The problems which arise are numerous and varied. They embrace electrical, mechanical and acoustical matters, as well as questions involving operation and showmanship as applied to sound pictures.

Electrical and mechanical troubles are as previously pointed out largely eliminated by frequent inspection and check of the equipment. A very thorough inspection of each individual part of the system is made at the time of completion of the installation and every six months thereafter. This is supplemented by inspections approximately every 10 days which, while not so thorough as the semi-annual inspections, serve to check the performance of the system as a whole as well as those particular portions which experience has shown require periodical attention. If anything un-

* Electrical Research Products, Inc., New York, N. Y.

usual in the performance of the apparatus occurs between visits this is investigated and the cause removed.

Correction of specific acoustic faults, whether echo, interference, reverberation or resonance, may be made with almost complete success. In extreme cases it is necessary to resort to surgical treatment but ordinarily relief may be obtained by the application of sound absorbing material in strategic locations. Although the question of acoustics is given attention at the time the installation is made the exhibitor may have neglected or only partially followed the recommendations formulated at that time. In such cases further study is undertaken and attempts are made to improve the acoustic results by rearrangement of the horns since slight changes in position sometimes produce noticeable differences. Additional studies are necessary after the completion of any acoustic change whether surgical or medicinal.

Operation and showmanship are so closely related as to be inseparable. The operation of the equipment presents a greater problem than is presented by apparatus failures. Although the system may function perfectly the effect in the theatre can be unpleasant and unnatural because of improper sound level. In fact undistorted sound when too loud is at times more objectionable than distorted sound at proper level.

Sound level is controlled by means of the fader located on the front wall of the projection booth. It introduces attenuation, in steps of approximately 3 decibels each, into the circuit between the pick-up device and main amplifying system. As these steps are fixed the output energy delivered by the system is normally the same for any given fader setting. Consequently, if the proper settings for a production are once determined and recorded, the projectionist need only follow a cue sheet to insure uniform results.

The output energy required is partly determined by the size of the audience because of its absorbing power. This effect varies in different theatres depending upon acoustic conditions but ordinarily the difference between empty and full house fader settings does not exceed two points. Therefore, the operator must be advised of the size of the audience so that he will know whether to use empty, half or full house cues.

The necessity for careful rehearsal is obvious, but strange as it may seem, continual pressure must be brought to bear on many

exhibitors to induce them to arrange and supervise rehearsal of their program. This may be due to past experience where reliance has been placed upon stage directors, muscians and actors. Whatever the cause, serious attention is being directed to the importance of controlling sound level of music and speech to insure naturalness and to augment the effect of the action or dialogue upon the emotions of the audience.

Another and closely related problem is presented by the theatre which persists in operation at too high a sound level. When reverberation is excessive in the house, the results are further aggravated; for the greater the energy supplied, the longer the sound will be sustained by reflection from surface to surface, before it is sufficiently absorbed to be inaudible. Raising the sound above natural level results only in unpleasant effects and does not improve intelligibility. On the contrary intelligibility usually suffers since the complex speech sounds overlap and no longer retain their relative intensities. Obviously the level in such cases should be maintained as low as possible for comfortable audition. Frequently, however, it is difficult for managers to appreciate this fact except through public reaction which may not be immediately apparent. (See Note.)

Success in detecting and remedying improper conditions in theatres before they are sufficiently advanced to effect reproduction seriously depends largely upon the ability of the service personnel to recognize slight depreciation in quality. Ordinarily this depreciation is first apparent at the extreme ends of the frequency characteristic, particularly the higher portion where small changes are less easily recognized. When it is recalled that the average human ear will not detect changes of less than 50 per cent in the sound energy of reproduced music or speech, except when directly compared and when so compared will only respond to changes of 20 per cent or more, the value of good hearing and aural training will be recognized.

In selecting personnel for servicing theatres certain specific qualifications are sought; among these are:

1. An attractive personality and appearance

Note: To illustrate faults of operation a short reel was shown. It was first run properly and afterward repeated as might be expected in certain theatres.

2. A knowledge of the fundamentals of electricity and mechanics
3. Good hearing

The service engineer is the main point of contact between the exhibitor and the company. He must obtain the respect and confidence of the theatre personnel in order to assure that cooperation which is essential to the realization of the best results. Through the service engineer the system is maintained in proper operating condition and the exhibitor is informed of the latest developments in the art. Through the service engineer the company obtains field requirements which influence the trend of future development.

The importance of determining the response characteristics of the ears of field personnel was not fully appreciated until several hundred theatres had been installed. For this reason a number of engineers have not yet been examined aurally. Eventually, however, a record will be available for each man.

Aural records are made with the assistance of a device known as the "Audiometer." In effect this instrument measures the sound energy supplied to the ear of the subject at the threshold of audibility. Various frequencies, in the speech and music range, produced by an oscillator are reduced by successive small increments until barely audible at which points the readings are made. It may be pointed out that impairment of hearing at certain frequencies only is more objectionable than a general impairment affecting the whole audible range equally.

Men selected for field work are subjected to a course of instruction extending over a period of three weeks. The curriculum includes recording methods and description of apparatus employed, a thorough study of each piece of equipment utilized in theatre reproducing systems including the system wiring diagrams, the mechanics of installation, architectural acoustics, the theory of horn placement and finally, aural training designed to facilitate the recognition of the presence or absence of the various portions of the frequency range.

Upon satisfactory completion of a comprehensive examination at the conclusion of the school the men are assigned to installation work where they receive practical training under the tutelage of experienced engineers. After assisting with several installations they become Installation Engineers in complete charge of such work.

As previously stated, service begins upon completion of a theatre installation. Consequently the personnel demands of the Service Department depend upon the installation schedule and are met by transfer of Installation Engineers to service work.

The Service Department is divided into two branches. One of these performs the function of making the thorough inspection at the time of completion of the installation and every six months thereafter. In addition it is called upon to investigate unusual cases of trouble which appear from time to time. The other branch makes the periodical check on theatres approximately every ten days and corrects ordinary emergency troubles that may occur.

The engineers of the first mentioned branch are given further training to supplement that received in the Installation School. This training includes a review of parts of the previous course and supplements others with more theoretical information than was previously presented. Great stress is laid upon aural training, particularly with respect to the recognition of the presence or absence of the higher frequencies which are so essential to brilliance and naturalness.

In conclusion, a demonstration of the effect of eliminating certain frequencies from the response was given with the aid of electrical filters.

TYPICAL PROBLEMS IN PROCESS PHOTOGRAPHY

CARROLL DUNNING*

ONE of the early motion picture spectacles was created by buying two old locomotives and having them crash together in a head-on collision. The engineers had pulled open the throttles and jumped prior to the impact. A couple of empty engines butting each other will not suffice today. The human element must be included in the shot. You must appear to maim at least one engineer and strew the track with the injured, or the option on your employment contract will not be renewed.

The present scenario specifies thrills too dangerous for even stunt men to attempt, and the exhibitor insists upon "big situations," too costly for the most extravagant producer to pay for.

The trick photographer was born and filled the niche for awhile with split mats, double printing, etc. But a wise public soon became critical and demanded realism. This necessity has created in Hollywood a small group of men, who are outstanding in their versatility and resourcefulness. Some are under contract with the large studios, others are free-lancing. Problems are presented to them at a moments notice, which require an adequate understanding of mechanical, electrical and illuminating engineering, a proper appreciation of art and a due regard for dramatic values. The misnomer, "trick men," still sticks, but they are the true "photographic effects" technicians of the industry.

Of the hundreds of nuts they are called upon to crack, I will present a few.

Scene No. 342 in a recent aviation picture called for a semi-closeup of a prominent actress flying above the ocean wastes (there must be no vessels or land in sight). She could not fly and refused to go as a passenger. The shot across the plane was too close to use a double. A studio technician, who is also an aviator, filmed the ocean minus the plane from a five hundred foot elevation, and, incidentally, went about ten miles off shore in a land plane because he knew he would get a better cross lighting effect. From his ocean negative a balanced colored transparency** was made, and through

* Dunning Process Co., Hollywood, Calif.

** Described in the September, 1928 S.M.P.E. Transactions, under heading "Composite Photography."

the latter, the actress and aeroplane were "doubled in" at the studio. Of course, all of the movement of the original aeroplane, in its ever changing relation to the ocean beneath, was imparted to the "doubled in" shot, even though the actress emoted in a perfectly stationary plane sitting on the stage floor.

Scene 128, in another picture, called for a love scene on the stern of a pleasure yacht in mid-ocean, with dialogue between star and hero and a love song by said hero. The silent version had been shot some weeks previously on a chartered boat rented at $400 a day and the owner had sensibly refused an attempt to load a five ton sound recording truck on his private yacht. So, 300 feet of ocean was photographed from the Catalina excursion steamer and doubled in with a balanced transparency as described in the preceding example. The yacht stern consisted of eight square feet of floor boarding, a railing, wicker seat and a flag pole. The sound of the side-wash of the water was picked up by hanging a microphone over a water-filled box through which a workman swished a wooden paddle. A second "mike" picked up the dialogue and song while a third recorded the orchestral accompaniment of a Hawaiian orchestra, supposedly amidship of our nailed-to-the-floor yacht. The composite photography was completed instantaneously and simultaneously with the recording of dialogue, song, music and sound effects. The result on the screen was startlingly realistic.

Scene 321 specified the explosion of a gasoline tank under the cowl of an auto, enveloping the agonized driver in flames. In the first tests, it was found that gasoline burned so violently that it left no unexposed silver in the negative on which to photograph the double-exposed driver. Finally, by blowing an ignited alcohol vapor across a container filled with a mixture of potassium chlorate and powdered sulphur, the flame retained its transparent character to its full heighth, because the liberated oxygen from the potassium kept the flame tongues more or less a thin blue to their extremities.

Scene 19 required a miniature dam to be blown up by the villian and the released water to rush almost into the lens of the camera. A week was spent in constructing it and when the dynamite cap burst the walls, a gob of mud plastered itself on the camera lens. The resultant negative looked like a micro-photo of a magnified polyp. The dam had to be rebuilt and reshot.

A short time ago, a producer considered the advisibility of sending a picture company to Italy. The dramatic portions of the story were night scenes along the Venetian waterways. To give the feature what is known as "big production value," it was necessary to open with an establishing shot showing the principals in an actual gondola passing through the Grand Canal. The electrical department immediately tabooed such a plan for they knew there were not enough lights in all Europe to illuminate Venice from the Rialto bridge to the Lido ferry. The technical supervisor solved the problem by building an exact replica in minature on a scale of one inch to the foot.

Even the smallest detail was carried out down to the little wired and lighted electroliers in the Plaza of Santa Maria. The church itself was a work of art. When finished, the floor of the stage was flooded with water to a depth of eight inches covering about an acre in area, and Venice stood complete and realistic. A motor driven camera, with lens six inches from the waters surface, was mounted on a board and floated through the canals, photographing the panoramic scene as it moved along. Into this scene was doubled a semi-closeup of the two principals seated in a full size gondola. The realism of the resultant composite photography, which also showed the rowing gondolier on the stern, would never be questioned by any audience.

Relativity is an important factor in all miniature work. If the scale representing an English countryside traversed by a railroad is built one inch to the foot, it is a simple matter to construct the railroad station and the farm houses of the correct size, but the regular straw is too large to represent roof thatching. Perhaps the strands of an unraveled rope will be more down to scale. For the gnarled trunks of the old Royal oak trees, an inverted root and base of the California grape vine proved excellent. The foliage of the tree was reproduced by pegging into the upturned root some sprigs of the Juniper bush. The railroad track had to be specially cast because the English track shows a clamp to every tie while the American rails are clamped only intermittently. Close-ups of this miniature demanded correctness to avoid criticisms from audiences in England.

Nervous breakdowns occur often among the supervising technicians. Imagine spending four months and $40,000 on the miniature

flood scene in "Noah's Ark," which was incorporated into life size foreground action. The temple in the middle distance and every house in the city beyond was cast individually from models. They were then set into position in an area 300 feet wide and 250 feet deep. Water flumes were laid underground, emerging at the proper points. Perforated pipes were installed overhead for the rain. Then every house was removed, broken apart and reset with clay in the broken joints in order that the flood would break them up realistically. As a precaution, wires were tied to pull them apart if the water failed and as a second precaution, dynamite caps were wired to a remote control. An immense tank containing 600,000 gallons of water was built above and to the side of the set.

Three hundred actors were on the life size set in the foreground. One hundred and five skilled men were at the various stations controlling wind machines, rain, flood water, lightning and other effects. Eleven high speed cameras with various focal length lenses were hidden between the foreground set and the miniature. Four normal speed cameras were on the foreground action. The high speeds picked up the individual details. The shot had to be photographed between 11:45 A.M. and 12:20 noon, otherwise the sky backing behind the miniature would cast a shadow. It took nerve to flash the starting signal for there could be no retakes. Fortunately, it was not necessary, but the supervising technician spent four days in bed from the nervous reaction. The Johnston flood, done a few years ago, was a parallel case with a similar successful issue.

Where long distances are represented in a short depth, a forced perspective is resorted to and consequently miniature buildings have the physical appearance of cubistic nightmares, but you can rest assured they are geometrically correct. For this and other reasons, a trained technician insists upon being left alone and even refuses to let a director see anything until it is on the screen.

I know of a case where the studio equipment provided a gravity railroad, but the scenario called for a train climbing the turns and grade in the snow-covered Alps. So the ingenious technician tipped all the trees, telegraph poles etc. out of perpendicular and even built all the roadside houses leaning forward at an acute angle to the track. The train was photographed coming down hill but on the screen it was going uphill.

When glass top shots are photographed simultaneously with the action on the lower portion of the picture, the shadows must be

painted to conform to the position of the sun on the lot. This requires a prearrangement with the director as to the time of day he expects to shoot. An improved method is to make the action shot first and by securing a balanced transparency from the negative, the glass top portion of the scene can be superimposed in the laboratory and thus the shadows of the glass scene can be painted to correspond with those found on the action negative. The portional scene on the glass automatically replaces the undesirable portions of the original shot.

It never rains in California unless a technician leaves a sky backing on the lot overnight. Recently a clever avalanche set had been tested and was ready for the next morning's schedule, when ice would tumble down the foreground miniature ravine, and in the middle distance, several tons of corn flakes would be dumped upon one of our most pampered stars. It rained during the night, and Mount Blanc in the background, covering 1,200 square feet of photographic enlargement, was found rolled up in a heap underneath the scaffolding.

Scene 83 required a French cruiser to pass a fortress at a harbor entrance and just miss being blown up by a submerged mine. It seemed more feasible to build a stationery fortress and to move the water and cruiser past it. A roller propelled tank about thirty feet square and a foot deep was built of 2 inch lumber. Repeated photographic tests were made, but the exploding dynamite just under the waters surface did not seem to throw the explosion high enough. About four in the morning when everyone was exhausted, the exasperated "powder man," weighted an extra charge and sank it to the bottom. Twelve inches of water happens to offer more resistance than a two-inch plank. Consequently, when the explosion occurred, 6,500 gallons of ocean landed on the floor of the stage and the cruiser had nowhere to go.

There is a slogan among the technicians, "It can be Done" and among the producers, "Do it."

Outside of the personal experience related, I am indebted to the trained artisans of the industry for much of the information given. Among my contributors are Ralph Hammeras, winner of last year's Honorable Mention Award of the Motion Picture Academy of Arts and Sciences; Fred Jackman, technical supervisor of Noah's Ark; Alvin Knechtol; E. Roy Davidson and Ned Mann.

THE UNIVERSAL CAMERA CRANE

FRANK O. GRAVES*

THE filming of a successful photoplay calls for mechanical skill of the highest order, not only in the picture itself, but in equipment used in conjunction with it. This equipment the public seldom sees, the effects only being shown on the screen; but without such equipment, the photoplay could not possibly be the finished product exhibited in theatres today.

A notable example of elaborate equipment used in the production of a motion picture in the huge camera "crane" used by Dr. Paul Fejos in BROADWAY. This "crane" was conceived by Dr. Fejos especially for the picture. The device was responsible for all the novel camera effects of the film, which have been so enthusiastically acclaimed by the critics, yet the crane itself cannot be shown to the public.

When the direction of both silent and sound versions of BROADWAY was assigned to Dr. Fejos by Carl Laemmle, Jr., they determined to dramatize the "personality" of the huge Paradise Night Club set, by getting photographic effects of its dazzlingly modernistic treatment never before brought to the screen.

This determination led to the conception of this novel piece of equipment. The camera crane consists of a six-wheel truck chassis on which is mounted a column. The top of this column supports a movable arm which is free to move on horizontal and vertical axes. At the end of this arm at a point of 25 feet from the center of the column is suspended a platform of 5 feet in diameter. The platform can be rotated through a complete circle and is connected to the movable arm by means of a trunnion in order that the platform will maintain a level position while the arm is moved from a horizontal to a vertical position. A pantograph cable connecting the platform with the pivot point of the arm gives positive assurance that the platform will always occupy a level position.

The platform is capable of supporting a live load of 750 lbs. in addition to the weight of the platform and the other revolving parts and with this load will rotate at a maximum speed of 13 r.p.m.

* Universal Pictures Corp., Hollywood, Calif.

The movable arm which supports the rotating platform will travel at a maximum speed of 600 feet per minute in a horizontal plane. This arm has a maximum raising and lowering speed of 400 feet per minute, this being its motion in a vertical plane. The truck on which all of the equipment is mounted has a maximum forward and backward speed of 500 feet per minute.

The motive power for the four motions, namely, truck, swing, hoist and platform rotation, as well as movement of the steering gear, is all supplied by electric motors.

The scheme of control is what is known as variable voltage and is substantially the same as that used on high speed elevators. Briefly it consists of a generator driven by a primary source of power. The armature of the generator is connected directly to the armature of the motor whose speed is to be controlled. By increasing or decreasing the field strength of the generator the voltage it produces is correspondingly raised or lowered and the speed of the motor to which it is connected is directly proportional to the voltage it receives.

On the operator's platform are mounted four reversible controllers directly connected to the shunt field of four separate generators, which in turn are connected to the four motors driving the truck motion, the swing motion, the hoist motion and the revolving platform motion. Reversal of the fields of the generator is handled by magnetic contactors mounted in a sound-proof cabinet at the rear of the truck. Movement of the controller handles in either direction first closes the corresponding direction contactor and then continues to strengthen the field of its generator and so increase the speed of its motor from zero to a maximum.

There are 20 speed points in each controller. This arrangement gives such smooth control of the speed that a person riding on the platform with his eyes closed could not tell when the motion was started or stopped.

From the foregoing it can readily be understood that the operator with a little skill can use any combination of motions to give any desired resultant motion; for instance, a wave motion can easily be obtained by operating the swing motion continuously in one direction and then alternately operating the raising and lowering motion. With the camera mounted on the platform and a proper combination of the four motions, it is possible to keep the action in focus at all times.

There is also a controller on the platform which enables the operator to steer the truck at will.

A duplicate steering and truck drive controller are also mounted on the main body of the truck just behind the front wheels. This makes it possible to make use of two operators when a complicated set of motions are desired. Inasmuch as many of these operations can be conducted at the same time while the camera records everything it sees, the photographic effects are indescribable.

Behind his camera on the platform, the cameraman can film effects equivalent to those which might be obtained on a particularly thrilling roller coaster or an airplane doing a barrel-roll. Swung vertically in a complete arc of 200 degrees, he may at the same time revolve the platform 13 revolutions per minute—all the while grinding his crank industrously. Extended upright, the girder is 50 feet from the ground, and it may be swooped down in two seconds.

To understand the complete power system of the crane it is necessary to start with the motor generator set which is mounted on a separate trailer. It is a five unit set, consisting of a 60 H.P. 220-volt D.C. driving motor direct connected to four generators, one 25 K.W. generator for the truck motion, two 15 K.W. generators, one each for the hoist and swing motion and a one K.W. for the platform motion. The set is started and stopped by means of a push button on the trailer acting through a magnetic starter also mounted on the trailer. The power is carried from the trailer to the crane truck by a flexible cable 250 feet long made up of 26 separate conductors. The cable is rigidly fastened to the trailer through a terminal board on the crane and is wound up on a motor driven reel. The reel motor is so connected with the truck motor that when the truck goes forward the reel unwinds due to the weight of the cable. When the truck backs up the reel motor operates at a speed proportional to the speed of the truck and winds up the cable.

The current is carried from the reel to the truck through a slip ring collector system having a separate slip ring for each wire. From this point the wires are carried up through the center of the column to the top where they pass through another collector system to the movable arm. They are then carried along the length of the arm to the trunnion supporting the platform. The connection between the arm and the trunnion is made through flexible loops as the movement between these parts is only about 200 degrees. From the trunnion to the platform the current passes through another

collector system and from thence to the controllers on the platform.

From the above it can readily be seen that the wiring system is the most complicated part of the crane.

The motor driving the truck motion is rated at 30 H.P. but will easily deliver 60 H.P. for short periods at a time. The motors for the swing and hoist motions are each rated at 15 H.P. The platform motion, the steering gear and the cable reel are all operated by ¾ H.P. motors, bringing the total H.P. of the motors on the crane to 62¼.

The following safety features are incorporated in the wiring to prevent any serious accidents.

There is a switch mounted on the floor of the platform which must be held closed by the foot of the operator before any power is supplied to the controller. In an emergency the operator has only to remove his foot from this switch to stop all motions in the shortest possible time.

The hoist motion has a spring applied, electrically released brake which will hold the moist motion in whatever position it happens to be at the moment power is disconnected. There is also a slow-down limit switch in connection with the hoist motion which automatically slows down the vertical motion as the platform approaches the ground, even though the operator may have the controller in the high speed position.

The swing motion also has a brake which stops the horizontal motion instantly in case the power should fail.

In applying electric motors to the different drives it was necessary to use fairly high speed motors in order to keep the weight down and this necessitated quite a speed reduction between the motors and the driven parts.

In the case of the truck drive, a 5 speed automobile transmission was used, which gave a 1 to 1 and four lower ratios with correspondingly higher torque. These low speeds with heavy torque are required when the truck is operated up an incline.

The swing motion is operated through a single thread worm wheel and one spur gear reduction. The hoist motion also employs a worm wheel and a spur gear reduction. The platform motion is handled through a single thread worm gear reduction, the steering motion likewise has one worm wheel reduction, while the cable reel uses 3 spur gear reductions.

The crane was used throughout those sequences of BROADWAY which were taken in the Paradise Night Club set, its swift movement being particularly valuable during the elaborate revue numbers when a chorus of thirty girls was used. It was possible not only to follow the action of the marvellously effective ensemble as the girls advanced to the foreground in the dance numbers, but at the same time to "zoom" upward and outward so that they were being photographed from all possible angles at the same time, without a break in the film.

This crane is so silent in action that it was used with perfect safety in the all-dialogue version of "BROADWAY" with the same ease with which it was used in the silent version.

The mechanical and electrical problems were so interconnected that close co-operation between the mechanical and electrical engineers responsible for the design was necessary at all times.

When it is realized that the transformation of a director's seemingly wild and impossible dream into a finished, smoothly operating mechanical and electrical marvel, was consummated in the short period of five weeks, it will be easy to understand why the personnel of the studios engineering and technical staffs must be composed of men not only with an engineering training, but who have also the hearts and courage to undertake the seemingly impossible things requested of them.

TELEVISION DEMONSTRATION

Dr. Herbert E. Ives*

TELEVISION requires apparatus for picking up the scene which is to be transmitted; converting the scene into electrical signals; transmitting these signals to receiving equipment and there optically recreating the scene by developing points of light corresponding in intensity and in position to the points of the original scene. The apparatus for accomplishing this, as developed in Bell Telephone Laboratories, was originally demonstrated by transmission over telephone wires from Washington, D. C., to New York, and by radio from an experimental radio station in New Jersey to New York, in April, 1927. The same receiving apparatus and equivalent transmitting apparatus were set up in the auditorium of Bell Telephone Laboratories for demonstration to the Society of Motion Picture Engineers. Transmission took place from one end of the auditorium to the other. The details of both transmitting and receiving apparatus were thus available for inspection by the audience. The operation was described and demonstrated by Dr. Ives, a member of the research department of the Laboratories who has been responsible for the co-ordination of the research and development work which led to the original accomplishment and to its subsequent advances.

* Bell Telephone Laboratories, New York, N. Y.

SEEING SOUND AND HEARING PICTURES

JOHN KLENKE*

THERE is really no paper to be presented. Only a few remarks will be made in connection with the showing of a short length of sound film.

Mr. Walter Damrosch, who has since the first of the year been conducting the National Weekly Radio Hour for the General Electric Company, recently visited Schenectady. We asked this well-known musician to let us make a short sound film of him at the piano. We wanted one of his typical explanations with music.

Mr. Damrosch spoke for a few minutes about his experiences during the day's visit to the General Engineering and Research Laboratories of the General Electric Company. He then said he would like to see sound as well as hear it, meaning that he would like to see sound photographed on film and projected on the screen. We accordingly made a print of the film and inserted on the side, by contact printing, about forty feet of the sound tract, showing the increase and decrease in the volume of the piano and of his speech. On the screen this has a different appearance from that of the work sound tract shown when the aperture gate is open. This, of course, is the cause of the 14½ inch difference between the record of the sound and the corresponding portion of the picture. A small section shows the difference between a musical sound tract and a sound tract of speech.

Mr. Damrosch is shown playing a note, and the increase of the sound tract modulations immediately appears on the screen showing the swelling in volume of the notes.

DISCUSSION

MR. TAYLOR: The presenting of a sound wave track or record so that you can see it while the sound is being played is a matter that has been attempted with more or less success since the days of the oscillograph, in which small ground glass screens show the wave corresponding to electric current or telephone currents, speech currents, or phonograph currents; but when it comes to putting it

* General Electric Company, Schenectady, N. Y.

on a large screen, it is not so easy, and an optical system handling enough light does not lend itself to working on such a small mirror. This has been done with some small degree of success, but with this development on the synchronized motion picture we have a new opportunity to do this, and I want to recall the fact that when I was working with a visual oscillograph about twenty-five years ago this occurred to me: that it might be worked into a method so that a deaf person could follow music or speech by sight. This is a very fascinating idea, but it involves tremendous difficulties. The comprehension needed by the person following the speech is tremendous. Taking a printed page worked into a sound track is a very long job, and some experience is necessary to follow it even though it can be presented in a proper manner. One difficulty has always been that the sound was not designed to stand still. A definite musical tone or chord which repeats after a fashion you can place before the repeating mirror so that the cycle will stand still, and it is easy, but speech is different because of the pitch going up and down, and varying pitch must involve forward and backward, slow or fast movement, and this explains the slow traveling of the waves in Mr. Damrosch's playing. If I had been present when this was taken I would have suggested f-sharp or *g* instead of *C* or something which would have been a multiple of 34 and some octaves of f-sharp tone would be a recording cycle matching with the intermittent showing of the picture, so that the sound wave would stand still. This method of showing a sound wave instead of having a cycle drawn out employs the cinema arrangement so that the film advances and then stops. It is different from the previous one showing the sound waves when they are produced and lends itself to what has been worked out by many audiences—a brilliant, well-lighted picture on the screen suitable for a large group. And this leads me to hope that there may be possibilities of clever deaf people learning to read by seeing the sounds come by. If they had learned to read from the lips, a good record would make this easier, and for that reason outside of the fascination which this is to me and I hope to others, in this kind of picture there may be real possibilities ahead for making use of it.

When Mr. Coffman asked me if I could round up papers for this meeting, Mr. Klenke was just starting to Panama and got back only two days ago, so that the title is not what he would have used, and if he had been here, it would have been possible to present

the speech as well as the musical tone. In one of the chords when Mr. Damrosch speaks, there are higher frequency components coming in. Mr. Klenke is going to see it through again with the gate withdrawn so that you see the working track in position. What you have seen is that printed on to go within the frame of the picture, and it is displaced with reference to the regular sound track, so that you have them adjacent, which is not the case in the ordinary showing. In the ordinary device, you see the track and then a second later hear the sound.

MR. F. H. RICHARDSON: Is it possible in the proposition you propose of looking at sound recording, made at normal speed without confusion? In order to understand it by sight you would have to have a clear record of all the peaks in the sound band.

MR. TAYLOR: Confusion is a relative term, and some people can look at a page and get the idea while others have to spell out the letters, and while it is possible to watch it, persistence of vision sets a limit. If you recall what I said before, it is not possible to present a sound wave standing still unless there is a recording cycle and a multiple of the frequency of the device which makes the frequency occur. Outside of reading the sound from the curve you have the difficulty of enlarging it on the wing.

(Projection of film repeated)

VICE PRESIDENT GAGE: I think it would have been well if it had been pointed out that the working sound record goes ahead of the picture, so that you get an idea of what you are going to hear by watching the sound track.

MR. F. H. RICHARDSON: I think we ought to talk these matters over. The motion picture industry is able to exist on what it takes in at the box office, and it is able to do this by giving the public what it wants. During the past year I have been requested by all sorts of people to send them sound bands. I don't think anything could be put on the theatre screen which would be more intriguing to the public than what we have just seen, if it can be done.

THE MITCHELL RECORDING CAMERA EQUIPPED INTERCHANGEABLY FOR VARIABLE AREA AND VARIABLE DENSITY SOUND RECORDING

C. R. Hanna*

THIS paper describes a small sized sound recording adapter designed to fit a standard Mitchell moving picture camera. The need for apparatus which is fairly light and portable has been felt for some time. Devices have already been designed which record sound on the same negative as the picture and these have proven a valuable supplement to recording apparatus using a separate film. This is especially true in portable work where small space is available and where quick setups have to be made.

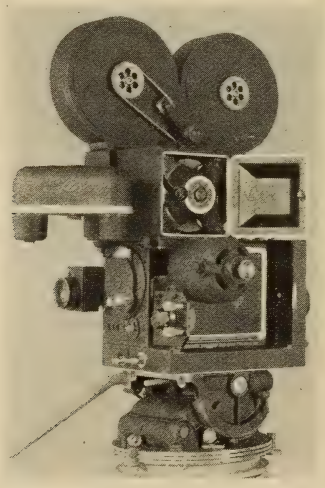

Figure 1. Camera and Recorder Attachment.

Figure 1 shows the right hand side of the new recording camera equipment. The attachment is placed between the camera and the magazine. Gearing between the camera and the recorder equipment is effected through a hole in the top of the camera where the takeup pulley was originally placed. A battery operated, shunt wound,

* West. Elec. & Mfg. Co., Pittsburgh, Pa.

motor drive gives sufficiently uniform speed without the use of a governor.

Inside the open door is seen the fly wheel filtering arrangement for obtaining a uniform motion of a driving sprocket on the opposite side. This fly wheel is driven through a very flexible spring which absorbs gear, and other, pulsations arising in the mechanical system. To prevent oscillations of the fly wheel and spring, a damping arrangement is provided. It consists of a leather brake lubricated with a light grease, pressing against the fly wheel. The whole filtering system is essentially the same as that designed for the RCA Photophone sound reproducing head made for the Simplex projector. The uniformity of film motion resulting from this filter is such that no pitch variation is noticeable even on sustained piano notes.

Figure 2 shows the film side of the machine. The constant speed sprocket is the one to the right in the upper compartment. The main feed sprocket in the camera maintains a loop of film ahead of this sprocket and the hold back sprocket (the one to the left in the upper compartment) maintains a loop following the constant speed sprocket so that no jerky motion will be transmitted through the film to the constant speed sprocket.

Recording is done at the sprocket. It has been found possible in this design to maintain a distance along the film of 14½ inches between picture and sound which is the same as that employed in all reproducing machines. This feature may not prove to be of any great advantage at present, but eventually, special printing apparatus may be developed, and if the standard spacing between the picture and sound is maintained in the negative, it is possible that the time required in printing will be greatly reduced.

The recorder optical system, at the right in Figure 2, is of the variable area type. It is shown with cover removed in Figure 3. The lamp on the extreme right illuminates a vertical knife edge by means of the condenser lens system just to the left of the lamp. This condenser also serves to converge the light from the lamp filament upon the mirror of the vibrating galvanometer shown in the foreground. The lens just in front of the galvanometer mirror focuses the illuminated edge upon a horizontal slit inside the barrel. The mirror oscillates about a vertical axis, and its angular position is normally set so that the slit is illuminated over half its length. The objective lens at the rear end of the barrel images the illuminated

slit at the film. As the galvanometer mirror vibrates, more or less of the length of the slit is covered with light, and a longer or shorter line of light occurs at the film. Because of the necessity of keeping

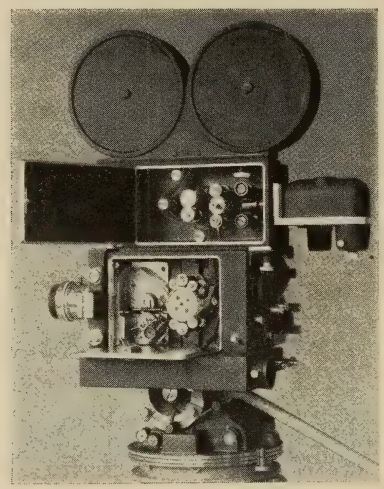

FIGURE 2. Left Side of Recording Camera.

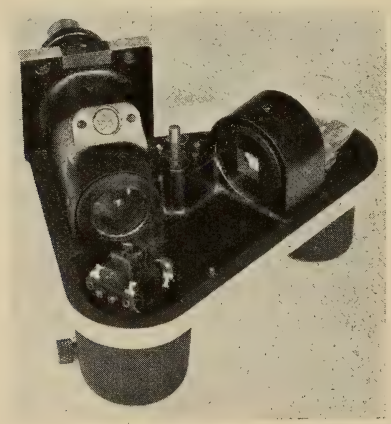

FIGURE 3. Variable Area Recorder Optical System.

the extreme travel of modulation within the length of the slit, a modulation indicator is provided. It consists of a clear reflector-glass, just ahead of the slit, which reflects a small part of the light

back on to a small ground glass shown at the top of the barrel. The image of the edge is cast there as well as on the slit. As the mirror oscillates, the extent of the modulation may be seen on the ground glass through a clear glass in the top of the optical system housing.

It was necessary to design a special galvanometer for use in this kind of service. The one shown is a particularly rugged piece of mechanism, little affected by vibration of the camera because of the large stiffness of its restoring member. It is of the moving iron armature type with four poles acting upon the armature. Its response to different frequencies is quite uniform up to 5,500 cycles. Considerable care in design was necessary to obtain this wide frequency response and at the same time keep the power consumption for full modulation down to a low value. It requires only 0.4 volt ampere to operate it, and this is readily obtained with one or two 171-A tubes in the output stage of the amplifier.

As the title indicates this machine may also be equipped with the Kerr cell type of variable density recording system which is shown in Figure 4. Such a system was described in detail by Messrs.

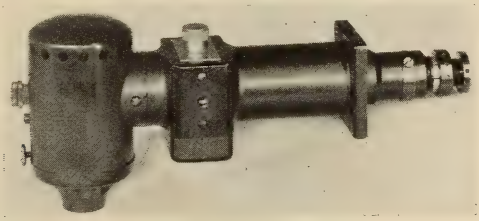

FIGURE 4. Kerr Cell Variable Density Optical System.

Zworykin, Lynn and Hanna in the Transactions of the S.M.P.E. in the Fall of 1928. The removable Kerr cell is shown in Figure 5.

Figure 6 shows the complete equipment with one type of portable recording amplifier. In most work, the amplifier is kept in the truck and long leads run to the camera; but it is seen from the photograph, that where necessary, it is possible to remove all of the equipment from the truck and place it on location. The storage battery and leads are the only things not shown in this photograph.

The amount of weight added to the camera by the sound recording head is about 25 lbs., making the total weight of the combination, minus the tripod, about 70 lbs. This is believed to be the lightest equipment yet devised for this work.

Credit is due the following men for their contributions to this development: E. H. Greibach and S. Sentipal, for the mechanical

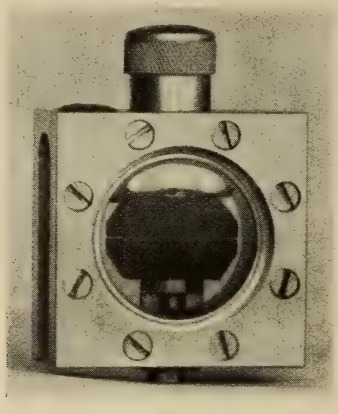

FIGURE 5. Kerr Cell.

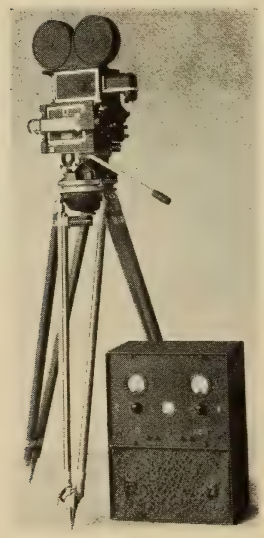

FIGURE 6. Complete Recorder Camera and Amplifier.

design; W. O. Osbon and K. A. Oplinger, for the design of the galvanometer and the galvanometer optical system; and L. B. Lynn, for the design of the Kerr Cell recorder system.

DISCUSSION

MR. MALKAMES: Have the ball bearings been eliminated in this camera?

MR. HANNA: Not in this machine. It is primarily for news reel work, and quietness is not so important.

DR. ROSENBERGER: Is the distance of 14½ inches adjustable or is it fixed?

MR. HANNA: This is determined by the projection machine. It would not have been necessary to hold this distance in the recording mechanism, because the sound track can be shifted relatively to the picture in the printing process. We maintained it because news reel work must be carried through in a hurry. The advantage will not appear, however, until special printers are developed.

MR. FAULKNER: In one of our releases after the picture was filmed, it was decided to put out a silent copy, and when the prints were received in New York, it was found that alongside the sound track a space showing the negative had been masked out. I did not know what the advantage was until now. I think it must have been taken with a Mitchell. After it was taken, they decided to make a silent picture; then there was no picture where the sound should have been.

MR. HANNA: Where the sound and picture occur on the same negative, it has to be masked.

MR. FAULKNER: I couldn't imagine why we had the negative masked off in the camera. I though it was being photographed full width and masked off in printing—but in this—it was "A Wild Party" with Clara Bow—since seeing your photographs, I think it must have been photographed with the Mitchell camera.

MR. HANNA: As the camera comes from the factory the aperture is not masked off.

MR. COFFMAN: I think I can answer by saying that the cameras on the Coast have the apertures cut for the size of the field on the sound picture. Some are Bell & Howell and some Mitchell, but all the cameras are arranged that way.

MR. FAULKNER: I understand they are not; I took it up with our laboratories.

MR. COFFMAN: Some of them are.

THE PYRENE COMBINATION AUTOMATIC PROJECTOR FIRE EXTINGUISHER AND ELECTRIC CUT-OFF

R. B. Dickson*

THIS device is designed to extinguish automatically fire originating in the projector or aperture head and to simultaneously cut off the motor. The latter action of course prevents further film being fed into the head. While extinguishing fire in the aperture head, Pyrene extinguishing liquid is sprayed into the upper and lower magazines in sufficient quantities to create an air dilution or atmosphere incapable of supporting combustion. With upper and lower magazines closed it is then impossible to ignite film contained therein.

The device consists of an aluminum frame or holder that is attached to the upper magazine, a special brass nickel-plated, one quart container to hold the extinguishing fluid, a C02 (carbon dioxide) gas cartridge with holder and firing mechanism and electric switch box. There are several feet of ¼ inch and ⅛ inch copper tubing, a master head, five spray outlets, fuse holders and a spare parts box.

The aluminum frame is designed to be fastened to the upper magazine, and the present screw holes are utilized for this purpose. Where present screws are not long enough, replacement screws are furnished by the manufacturer. Into the frame is fitted a special Pyrene container with quick opening top and a glass inspection sight. Running from the extinguishing container to a master head is a system of ¼ inch copper tubing. From the *master head* the tubing continues around the *upper magazine* to the valve or *roller holder* and *aperture head* and to the *lower magazine*. Brass nickeled cleats hold the tubing in place. At each of the points mentioned is placed a spray nozzle designed to direct the extinguishing fluid into these points in a proper spray. The spray nozzles are especially constructed and tubing proportioned so that the extinguishing liquid reaches the distributing points very quickly and in proper quantities. The upper and lower magazines, the roller holder and the aperture head must be drilled in order to take the spray nozzles.

* Pyrene Mfg. Co., Newark, N. J.

Close to the liquid container is set the cartridge holder and firing mechanism. The cartridge is of drawn steel containing compressed carbon dioxide gas. The firing mechanism consists of a powerful steel spring set to a hardened steel firing pin or needle. When the firing pin is released it pierces the seal of the C02 cartridge and the C02 gas is released into the liquid container and forces the liquid to the various distributing points. The liquid seal of the container is of course opened at the same time. The action of the firing pin is controlled by a fuse band set in a fuse pan at the aperture head. This fuse band is a piece of film about ⅜ inch wide and 1½ inch long, cemented and riveted. This fuse band fits over two pins set close to an opening in the aperture head. One of the pins is connected to a spring that controls the trigger and firing pin. This spring is held taut by the fuse band. In event of fire the fuse will let go and release the trigger. The device will then function as outlined in opening paragraph.

To accelerate the action of the extinguisher, extra fuse is extended through fuse pan close to the aperture head. Heat from carbons will not ignite the fuse, and it will function only in case of fire.

The shut off action to the motor is controlled by relaying a special switch between the motor and projector. The special switch has a chamber fitted over a push button and connected by ⅛ inch copper tubing so that several pounds pressure of C02 gas is delivered at the switch. The motor shut off is accomplished instantly and with the discharge of the extinguisher liquid.

To load the extinguisher, Pyrene liquid is poured into the brass container. The top is closed. The cartridge is inserted in its holder, sealed end down. The fuse band is set over the pins. The fuse pan is held in place by inserting the pin inside of fuse pan through the fuse. The firing mechanism is then cocked, and the handle returned to hold the C02 cartridge in place. Before testing the extinguisher, all unions and nozzles should be tightened. The device is then ready to operate.

The attaching of this extinguisher to the projector is accomplished in 1½ to 2 hours. Printed instructions with blue print drawing are furnished by the manufacturer. When set up, the device does not interfere with the projectionist in any way. It requires a minimum of attention and does not have to be recharged unless used.

The extinguishing liquid does not damage the film or projector parts. It cleans oil or grease from the parts touched, and it is only

necessary to recoil the feed mechanism in the projector after they have been in contact with the liquid.

The action of the extinguisher is very rapid. The extinguishing of the fire and shutting off of motor is accomplished in 3 to 4 seconds from the time the fuse operates. The film can be repaired and run again in a few minutes. With a few changes in tubing lengths this extinguisher can be adapted to projectors with sound attachments. Here, too, parts are so placed that they do not interfere with the operator.

The device is very substantially constructed and it should be serviceable for many years.

DISCUSSION

Mr. G. C. Edwards: In the city of New York alone, if this type of apparatus had been installed in all theatres, we would have been saved the last year, a loss of over $14,000. That is the amount of claims I handled myself for the last year. We have tested this four or five times in succession, and at no time have we had fire more than two seconds after.

Mr. Golden: Is that apparatus sold, or is it only rented?

Mr. Dickson: The apparatus is sold outright to the purchaser. Approximately $200.00 covers the cost of a full equipment, including enough spare parts to take care of it for over a period of two years.

Mr. Golden: I thought that tetrachloride did not put out a film fire.

Mr. Dickson: There is no extinguishing fluid known that will control a large quantity of film where it is loosely rolled. What we do is to put the extinguishing fluid in the upper and lower magazines so quickly that fire cannot start. Note that we have a sufficient quantity of liquid going into the aperture to extinguish the fire that is in there. Of the film that I put in, nothing in the magazine is touched. If the fire gets into a large reel of film we cannot extinguish it, but we do put out the fire in the aperture.

Mr. Golden: After the liquid is put on the projector, how soon is the projector ready for operation? What is required to put the projector back into shape so it can be run?

Mr. Dickson: It is necessary to oil the rollers. The Pyrene wipes the oil off It is one of the best degreasers known.

Mr. Gejman: Would you say five or ten minutes after?

MR. DICKSON: I should say it would depend entirely upon the operator. The extinguishing liquid will dry very quickly, or can be wiped off.

MR. GOLDEN: Is there no effect on the film?

MR. DICKSON: In our opinion, the liquid does not affect the film adversely.

MR. GELMAN: How much of the liquid goes into the magazine?

MR. DICKINSON: There are five outlets. Considerable of the liquid goes into the aperture; the balance, into the magazines.

MR. GELMAN: How much of the liquid goes into the magazine to cause the film to streak?

MR. DICKSON: This liquid will not hurt the film. Many operators use this fluid to clean film.

MR. EDWARDS: In the particular operation, there is a delay of not more than one minute. It is perfectly possible to pull down your film and rethread and go on. After, you can go to your oil can and oil up.

MR. HILL: I want to ask if there is any difficulty in removing the liquid from the film after the fire? How much labor is required to clean the projector after the fire? Will it affect the mechanism?

MR. DICKSON: Mr. Hill asked will it affect the mechanism? It does not injure the film. It would take but a moment to wipe out the magazine, and you must oil the rollers. It will take the oil from the rollers. Cleaning only takes a few moments.

MR. HILL: That cartridge—is that the same one used in a carbon syphon?

MR. DICKSON: Yes. This carbon dioxide is the same as used for High balls. I might say it is necessary to take care that the proper amount is contained. These cartridges are carefully weighed to see that the proper amount of gas is contained.

MR. C. H. CLARK: I want to ask if the fire smokes the lens?

MR. DICKSON: I have demonstrated this many times. I would say I have shown this more than forty times, and I have never found any smoke on the lens. However, I can see that it might happen. That would be determined by the length of time the fire were to burn. The possibility is slight, as the liquid reaches the fire in two seconds.

MR. CRABTREE: What is the mechanism whereby the fire operates the machine and pierces the cartridge.

MR. DICKSON: There is the fuse, about 3/8 inches wide. A piece of film without emulsion. This box is a spare kit box containing cartridges and fuses. We do put a small accelerating fuse at this point. It can be a piece of film. It is a bit smaller than the floss.

MR. ROSS: Does it empty the entire cylinder, and do you have to renew the cylinder for each fire?

MR. DICKSON: There is sufficient gas to discharge the entire contents of this container. When the liquid has gone down to the bottom, there is gas left. The contents would be entirely discharged.

MR. ROSS: I noticed the fire was extinguished so quickly.

MR. DICKSON: In the event of fire, I think the preservation of the liquid would be a small item. There is no object in conserving the fluid. The object is to put out the fire. By opening this valve the gas comes out quickly and that saves the rest of the liquid. When I began this experiment, the container was one half filled.

MR. A. S. DICKINSON: How much loose film did you put in the magazine?

MR. DICKSON: About one foot.

MR. DICKINSON: How much was burned?

MR. DICKSON: Practically all of the loose film was consumed. This morning I took out about one-half of what I put in. The determining factor is the length of time it takes the fire to reach the fuse.

MR. ROSS: Is it a fact that the film furnishes its own oxygen?

MR. DICKSON: Yes. If we did not put an accelerator in there, the film would burn until the flame reached the fuse operating the firing pin.

MR. MANHEIMER: How is CO_2 used for the energizing gas to force the liquid thru? What advantage has the carbon tetrachloride over the CO_2?

MR. DICKSON: You cannot depend on carbon dioxide as you can on the liquid carbon tetrachloride. The carbon dioxide gas to be really effective must be contained. Another thing is that a container large enough would weigh quite a little. We do not feel it would be as practical as the carbon tetrachloride. We find this is the best type for this particular type of fire, and the most adaptable to this form of machine.

MR. CRABTREE: The efficiency of the tetrachloride lies in the fact that it conducts the heat away, and carbon dioxide will not do so.

The flame would actually burn in carbon dioxide. The only way to extinguish it is to kill it by water or tetrachloride of carbon.

MR. MANHEIMER: Water would not extinguish the fire. Does not tetrachloride exclude oxygen?

MR. DICKSON: We have not found that we can extinguish nitrous cellulose film with water or even carbon tetrachloride. Only by getting Pyrene on the flame quickly, can we put out the flame. I have seen nitrocellulouse film soaked with water from a 2½ inch hose, buried underground, and come up smiling and burst into flame. The real virtue of our machine is the quickness with which we put out the fire.

MR. CRABTREE: I quite agree that once the temperature of the film gets beyond a certain point, no water can put it out, although you can retard the combustion. But what happens if you use water instead of tetrachloride in this instrument?

MR. DICKSON: I do not believe it would be practicable or desirable. When our liquid strikes the flame, it makes a gas. When carbon tetrachloride strikes the heat, it goes back to its original form, a gas, which is very heavy. The gas is the extinguishing element. Fire cannot start in the upper or lower magazines of the projector as our liquid would be there cooling these spaces.

THE RESULTS OF THE EXPERIMENT WITH EASTMAN CLASSROOM FILMS

T. E. Finegan*

AT A meeting of this Association, held at Lake Placid in September, 1927, I had the privilege of presenting a general outline of the plan and scope of an experiment in classroom films which had been undertaken by the Eastman Kodak Company in cooperation with the National Education Association. Today I am to present the results of that experiment.

It is desirable, at the outset, to have a clear understanding of the conditions and reasons which made it appear advisable to the teachers of the country to have this experiment conducted. The opinion was common among teachers, and others who had had experience in the use of films, that motion pictures could be utilized to great advantage as an aid in classroom instruction.

Films had not, however, attained a recognized position in schoolroom practice. Their use in the schools was not only generally restricted to the service of the auditorium or general assembly, but they were intended more for entertainment than for systematic instruction. Very few films had been especially developed for the service of teachers in their regular daily work in the classroom. The films generally used were either made by industrial or commercial corporations for propaganda purposes, or they were assembled from extant material obtained from various sources. No criticism of these films is intended. They rendered good service to the schools which were fortunate enough to obtain them. The point is made simply that these films were not prepared for teaching purposes and could not, therefore, yield the full measure of service that films prepared especially for giving instruction on a classroom topic would provide.

No adequate experiment to determine the value of films as teaching aids had been made, nor had an experiment been made to ascertain if there were losses which would outweigh the gains afforded. The effectiveness and the value of motion pictures in classroom work was more a matter based upon individual opinion

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than upon exact knowledge. Under these conditions it did not appear that motion pictures could be given general recognition as a teaching agency until definite and reliable information, based upon a comprehensive and definite experiment in their use, was made available.

Under the conditions which have been described three fundamental questions were presented:

1. May a series of motion pictures be developed which are co-ordinated with modern standard curriculums, and which will be effective teaching agencies?

2. May a reliable measure be obtained of the contribution of such films in regular classroom service?

3. If there is a gain in the effectiveness of instruction in the use of such films, is it sufficient to justify the expenditures required to make them available to the schools?

The purpose of the Eastman experiment was to reveal basic knowledge, not only upon these practical questions, but also upon the essential features of a sound classroom film program.

A knowledge of the details of the plan of the experiment, and of the thoroughness with which such details were executed, is essential to an adequate appraisement of the reliability and significance of the results obtained. These will be stated briefly:

The enterprise was organized in twelve cities, widely distributed throughout the United States. These cities were Newton, Mass., Rochester, N. Y., New York City, Winston-Salem, N. C., Atlanta, Ga., Detroit, Mich., Chicago, Ill., Lincoln, Neb., Kansas City, Mo., Denver, Colo., Oakland, Calif., and San Diego, Calif. The Atlantic Coast, the Central West, the South, the Mountain States, and the Pacific Coast were represented in this experiment.

There was such general enthusiasm and such a fine spirit of co-operation manifested in each of the cities that more classes were organized and a much greater number of pupils included than we had anticipated would be possible. This of course makes the experiment of much greater value. Approximately 11,000 pupils were organized in 300 classes under the instruction of 200 teachers. Two courses of study covering a period of twelve weeks each were prepared. One course was Geography in the fourth to the sixth grades. The other course was General Science in the seventh to the ninth grades, or the junior high school.

The pupils pursuing each of these courses were divided into two groups. One of these groups was known as the experimental group. There were no restrictions or requirements on this group except that the films prepared for this experiment should be used in an adequate manner. In this paper the experimental group will be called the *Film Group.*

The other group was known as the control group. There was one restriction placed upon this group. The use of motion pictures in their classes was, of course, prohibited. This group did, however, use photographs, charts, diagrams, stereographs, slides, and other illustrative material. In this paper the control group will be called the *Non-Film Group.*

Thus there was in each of the twelve cities participating in the experiment one film class for each non-film class in each of the two courses. The number of pupils in each film class was approximately the same as the number in each corresponding non-film class. There were about 7,500 children in the Geography classes, or 3,750 in each group, and there were about 3,500 in the General Science classes, or 1,780 in each group. In nearly all cases the film groups and the non-film groups were in different buildings.

It is obvious that in an experiment of this type in which the superiority of devices and results are to be measured, the instruction of each group must be confined to identical areas. The course of instruction in each of the two subjects was built around ten topics. The topics and the order in which they were presented were as follows:

Geography	*General Science*
1. New England Fisheries-Cod	1. Hot Air Heating
2. Wisconsin Dairies	2. Atmospheric Pressure
3. Wheat	3. Compressed Air
4. From Wheat to Bread	4. The Water Cycle
5. Cattle	6. Purifying Water
6. Corn	5. New York Water Supply
7. Cotton Growing	7. Limestone and Marble
8. Irrigation	8. Sand and Clay
9. Bituminous Coal	9. Reforestation
10. Iron Ore to Pig Iron	10. Planting and Care of Trees

Detailed Study Guides were prepared on each of the above topics. This enabled all the pupils participating in the experiment

to direct their study upon the same body of material. These guides were also of service to the teachers of each group by prescribing the general limitations of the field which the instruction should cover. The Geography guides formed a syllabus equivalent to 69 printed pages. A copy was given to each of the pupils in each of the two groups. The General Science guides formed a syllabus of 60 printed pages and a copy was given to each of the pupils in each group receiving instruction in this field. These guides were uniform in plan of organization, and contained headings and subheadings of each topic and notations of the various aspects of these divisions. They also contained elaborate notes in highly compact form upon the important features of the topics in general. In fact these guides served the usual purpose of a text book.

The teachers of the film groups generally were without experience in the use of motion pictures. No teaching technique in the use of motion pictures had been worked out, and the teachers were not skilled in the use of a projector. They started in the experiment with this disadvantage. To meet this situation Teachers' Guides were prepared. These guides were purely suggestive. They indicated in a brief way how and when to use the films. Teachers, however, were given a free hand in their own method of the use of the films. The non-film teachers were not accorded the use of these guides. The films and the Teachers' Guides suggesting the plan under which the films should be used were the only aids accorded the film teachers which were not accorded the non-film teachers.

It was intended in carrying out the experiment that each class should be conducted under normal conditions, and that the children and teachers should maintain the usual study habits and attitudes toward their work in these courses that prevail in normal classroom instruction. Teachers were urged to regard their part in this experiment as if they were teaching a regular course prescribed by the school authorities for all the schools of the city, and to avoid if possible the development of a spirit of rivalry between the two groups.

It is an essential requisite in an undertaking of this type that the two groups participating in it shall possess a common level of intellectual ability. To approximate this condition as closely as possible, the school having a film group was selected in the section of the city having the same general home environments and the same

racial, social, and economic background that the school having the corresponding non-film group possessed. An examination was also given to ascertain the intelligence of each group and to ascertain the achievement of each of the Geography groups in the subjects included in their course of study. A similar examination was given to ascertain the achievement of each of the groups in the General Science subjects.

It was likewise important that the teachers placed in charge of the two groups should be of equal training and teaching ability. The superintendent of schools in each of the cities selected the teachers for the experiment in his city and so far as it was possible to determine, chose teachers upon this basis.

In order that the experiment might be conducted on a sound professional and scientific basis, and without prejudice in either direction, it was placed under the charge of two leading educators of the country who are experts in testing and measuring practices and accomplishments in school procedure. The men chosen were Dr. Ben D. Wood, of Columbia University, and Dr. Frank N. Freeman, of the University of Chicago. Each of the twelve cities, except the two on the Pacific coast, were visited by one of these directors before the work of the experiment was opened. The importance of an honest, thorough, professional contribution by the teachers was pointed out. The purpose of the experiment, its value to educational practice, and the conditions under which the whole enterprise should be conducted were thoroughly presented to all teachers identified with the undertaking.

The classes in each group in each of the cities, except the two on the Pacific Coast, were visited by one or the other of these directors during the progress of the experiment to ascertain if the experiment was being properly carried out, and also to get first hand information on the use of the films as a teaching device.

Considering the general scope, the number of teachers, pupils, schools, and school systems involved, the extensive and detailed preparations for it, the period of time it occupied, the funds expended in conducting the enterprise and its importance to educational interests, the Eastman experiment is the most outstanding experiment in education that has ever been conducted.

The next important aspect of the experiment to be considered is the type of film used. The scenarios on which the films were based were prepared by groups of trained, experienced teachers.

Each topic was studied to determine the fundamental knowledge related to it which should be presented in the classroom. Those features of these basic elements which are readily adapted to motion pictures were incorporated in the scenario. In other words, the first determination was, what material on this topic might be shown more clearly, accurately, and comprehensively with the aid of motion pictures than by means of still pictures and other teaching devices?

In developing these scenarios no thought was given to entertainment aspects of a film. The traditional story and the usual dramatic features of motion pictures were purposely avoided. The scenarios were prepared with the sole thought that the films developed from them should be rich in teaching material and an effective aid in the hands of a teacher in her classroom instruction.

Having specified in the scenario the type of film best adapted to the teachers' needs in giving the instruction required in the courses specified for this experiment, we then proceeded to obtain the scenes necessary to the production of such films. The films used in the experiment were thus developed. There was one film for each of the topics in each of the courses. The procedure, therefore, in preparing scenarios and in the production of the films was based upon a sound teaching philosophy.

The films used in the Eastman experiment were not planned to make the work of either the pupils or the teacher easy. There is no royal road to learning. Schoolroom devices, practices and methods should stimulate the mental activities of a child and cause him, through his own efforts, to explore new fields of knowledge and to acquire an interest in the manifold phases of our social and economic life.

These films, therefore, were not built to do the thinking for a child which he should do for himself. They were constructed upon a plan intended to arouse the child's mental powers and thereby stimulate his interest in the subject presented by the film. They were designed to create in the child's mind a desire for more information, to induce him to ask questions, to lead him to make his own investigations, to become an accurate observer, to improve his descriptive ability, and to make application of his knowledge to new experiences and real situations.

The use of the film in this experiment was stressed to be that of a supplementary aid to the teacher. It was not used in any

way as a substitute for any factor in present classroom practice. The verbal explanations of the teacher, the text books, maps, charts, still pictures, and all other agencies which have enabled the teacher to illuminate situations or processes were used. The film simply took its place as an additional agency to render service in teaching where it is better adopted to perform such service than other existing agencies.

The directors of the experiment, in their report, confirm these general observations as to the place and service of the films when they state the distinguishing characteristics of the films to be as follows:

"First and foremost is the pedagogical nature of the films.

"In the second place, the experiment involved enough film material, and continued over a period sufficiently long so that the contribution of the films formed a large enough fraction of the total life experience of the individual for that period to be measurable.

"In the third place, these films became an integral and regular part of the curriculum and of the classroom procedure, so that in our comparisons we are concerned with the contributions of a normal classroom and curriculum agency, and not with that of a novelty.

"In the fourth place, this experiment involved a very large number of students in the six school grades from the fourth to the ninth inclusive, scattered in a dozen cities, taught by nearly two hundred teachers in about seventy-five different schools."

One of the purposes of the use of films is to give pupils a concrete notion of the appearance of objects, events, and conditions in the physical world. This experience is a valuable one for the pupil as it constitutes an important part of the foundation of his thinking and action. It is an appropriate attempt to measure the accuracy and vividness of concrete impressions obtained by pupils in the non-film group as well as by those in the film group. A comprehensive unit of instruction must include not only concrete experience but reflection and thought about this experience for the purpose of giving explanations and making generalizations. For this reason the Study Guides already described contained many items which called for discussion and explanation.

Some portion of the class time in each of the groups was, of course, occupied in the discussion of these topics. In other words, it was essential to a fair evaluation of the use of the films

to frame questions which would not only reveal the definite and clear cut concrete ideas which pupils had acquired, but also the value of such an agency to stimulate pupils to make adequate explanations of their experiences. Effective teaching in the classroom should result in a continued interest of the children in a topic on which they have received instruction, and therefore implies the practice on their part to think about that topic not only as it is presented in the classroom, but outside of the classroom as well. This interest of the children may be considered as undoubted evidence of the thought provoking powers of films.

With these considerations in mind two types of written tests were used. These were known as the Comprehensive Tests and Topical Tests. This procedure had two purposes in view. The first was to secure a broader and more reliable measure than could be obtained from one set of tests alone. If two independently organized sets of tests give the same results they strongly confirm each other. The second purpose was to measure somewhat different forms of achievement.

The Comprehensive Tests were given at the beginning and end of the experiment. They consisted of an extensive series of items organized on the plan of True-False and Multiple Choice tests. These tests measure judgment and reasoning to some extent as well as a knowledge of subject matter. By the use of tests of this type a knowledge of the film group and the non-film group could be measured at the outset of the experiment, and their comparative progress during the period of instruction could also be measured at the end of the experiment.

These tests were based exclusively upon the Study Guides which constituted the syllabi during the courses of study, a copy of which was given each pupil in each group at the beginning of the experiment as previously stated, to serve the purpose of text or study material. The first and second of these tests were constructed without reference to the specific content of the films, and related almost wholly to ideas and concepts such as are ordinarily presented in verbal terms and which are free from immediate visual material. The third of these tests was also based strictly upon the Study Guides with a view to testing the information, ideas and relations which could be derived from reading and from films. The directors in charge of this work stated that they purposely avoided in this test the framing of questions whose answers could be found

in the films and not in the Study Guides used by the students in each group.

The Topical Tests were intended to measure the attainments of the pupils upon each separate topic. This type of test also accorded the pupils somewhat greater freedom in organizing their answers, as well as in expressing themselves in other than verbal terms. In form, these tests were mostly of the essay type. The questions were of two classes, one descriptive and the other explanatory. In the descriptive questions pupils were asked to reproduce by words or diagrams the appearance of things which they had seen, or about which they had read. In the explanatory questions they were asked to explain why certain actions or events occurred as they did. Each of these types of questions was also based upon the subject matter of the Study Guides. In other words, scrupulous care was exercised to make sure that the pupils in the non-film group, as well as those in the film group, had ample opportunity to acquire the information which was called for in the questions used in each of the two types of tests. The tests were given at the completion of the instruction in each two topics. Five of these tests were, therefore, given.

All of the test papers used in the experiment were prepared by Dr. Wood and Dr. Freeman, assisted by graduate students of ample training and extensive experience in the formulation of tests. The tests were given on the same day and hour to each group in each of the twelve cities, and covered the same prescribed length of time. No teacher in the experiment was permitted to have any relation of any kind with any of the tests. They were not permitted even to see the test papers. A special representative of the directors in charge of the experiment was designated in each city. Either the Superintendent of Schools or one of his assistants, the Director of Research, a director of a division of instruction, or a school principal was selected to serve in this capacity. He received and administered all tests, and returned promptly all test papers written by the pupils. Comprehensive test papers were reviewed and rated under the immediate supervision of Dr. Wood at Columbia University, New York City. The Topical Test papers were reviewed and rated at the University of Chicago, under the immediate supervision of Dr. Frank N. Freeman.

The results of the experiment show that the work of the film groups was distinctly superior to that of the non-film group. The

film group *gained* more than the non-film group during the twelve weeks of instruction. In General Science, the average gain of the film group was 111 per cent of the average gain of both film and non-film groups taken together. In Geography it was 117.9 per cent of the average of both groups.

Not only did the film group gain more than the non-film group during the period of instruction, but the average score of the film group was *higher* than the non-film group at the end of the experiment, although the non-film group was superior to the film group in intelligence and grade placement, and made better scores on the tests given before the instruction began.

In General Science, the average score of the film group on a test given at the end of the experiment was 111.8 per cent of the average score of both groups taken together. In Geography it was 115.6 per cent of the average score of both groups.

On the essay type of test the average score of the film group in General Science was 111 per cent of the average of the scores of both groups taken together and in Geography it was 115 per cent of the average of the scores of both groups.

It will be noticed that these figures do not represent the superiority of the film group over the non-film group, but show the percentage by which the average of the film group is above the average of both the film and the non-film groups taken together. A simple illustration may make this clear. If one group of stocks average $10 a share and another group of stocks average $20 a share, the second group is 200 per cent of the first group, but it is only 133⅓ per cent of $15 which is the average of both groups of stocks taken together. In like manner the percentage in favor of the film group would be distinctly higher if based on the average of the non-film group instead of on the average for both groups.

The term "Standard Deviation" is commonly used by the specialist in educational measurements. There seems to be no simple way to make this term understandable in common language.

In General Science, the gain of the film group over the non-film group was 14.5 per cent of the Standard Deviation. The average of the film group on a final test given at the end of the experiment was superior to that of the non-film group by 78.2 per cent of the Standard Deviation. On the essay type of test the film group was superior also by 23.2 per cent of the Standard Deviation.

In Geography the film group showed a gain superior to the

non-film group by 33.2 per cent of the Standard Deviation. In a final test the average score of the film group was superior to that of the non-film group by 84.5 of the Standard Deviation. In the esssay type of test the difference in favor of the film group was 29.3 per cent of the Standard Deviation.

We have now given those concrete results achieved in this experiment which were revealed by written tests and which are measured on a percentage basis. There are, however, other results achieved by the skillful teacher in her classroom work which are vitally important and which go to the very heart of efficient instruction and of the real purposes of education, even though we are unable to measure accurately on a percentage basis their full significance.

The directors in their report confirm this viewpoint on the limitations of written tests. They say, "These tests, or any other written tests, could not adequately measure or even roughly register all of the contributions of these films. A large number of attendant features are embodied in each film that the tests do not reveal, but which afford a body of marginal material that greatly enriches not only the topics treated, but enriches also the incidental experience of the pupil."

The directors further pointed out a most significant service of the film which should be emphasized in any fair evaluation of the achievements of this undertaking. The material shown by the films was selected primarily because it was believed by the experienced teachers who prepared them that such material could be presented more clearly and vividly through motion pictures than expert writers could present it by means of detailed and elaborate written descriptions. The directors state that it is obvious that any written test would fail to bring out fully those aspects of a topic which were the prime considerations for the selections of the subject matter of the film on that topic.

Furthermore, as every person knows, whose experience has given him knowledge of the power and influence of the film, each film affords opportunities for the translation of visual impressions into verbal forms of expression that carry a quality of meaning far richer and more integrated than the meanings acquired through verbal impressions alone. On this point the opinion of the directors as stated in their report is most emphatic and conclusive. They say:

"It is doubtful if any known technique of testing can reveal adequately this difference. It is probable that the film groups' *visual impressions* were consistently in advance of *facility for expression.* The converse of this proposition follows, and that is, that in the non-film groups, instructed more largely through verbal forms, facility in expression naturally has a tendency to out-run the acquisition of meanings based upon experience with reality."

When the three hundred teachers who participated in this enterprise entered upon this work each one of them was requested to make a detailed report on the completion of each topic in the course. Near the close of the experiment each teacher was requested to express his opinion upon several features of pupil activities and interests during the period of the experiment which had transpired. The data supplied through such reports give much reliable information in evaluating the service of the films. Time will permit only a brief reference to these, and yet they constitute such a valuable contribution to the achievements obtained that they should be reported.

In considering this aspect of the experiment we should keep in mind that one of its primary purposes was to ascertain the magnitude and nature of the contribution which classroom films make to the usual objectives of good teaching, such as: the arousal and maintenance of interest; the development of originality and larger participation in self-activities; improving the quality of their reading material; increasing the ability to discuss topics and to write about them; enlarging the vocabulary; enriching personal experiences; correlating the work of the classroom with community life; developing the ability to concentrate mental activities; and many others. The attainment of these ends are among the most imperative and outstanding functions of the schools.

It was announced by the directors at the outset of the experiment that they would seek the unbiased opinions of the teachers upon these points. A summary of the opinions expressed by teachers at the end of the experiment indicates that:

1. Over 90 per cent of the teachers express the opinion that the films were highly effective in stimulating the interests of the children. Furthermore, they state that this interest was not a passing one but a sustained interest. Weeks after a topic had been demonstrated through the use of a film, the children would bring

material to the classroom related to such topic, but which had just come under their observation.

2. The teachers are almost unanimous in saying that the films stimulated their students to an extraordinary degree in undertaking projects and other types of self-activity. The types of activity were such as, the making of models of wind mills, tractors, schooners, farm implements, railroads, cotton fields, coal mines, and scores of other endeavors which were suggested to their minds by the film scenes and by their readings and which indicated that the films were a superior device in developing the imagination, skill and mental and manual knowledge of the children.

More than 5,000 separate articles made by the pupils were received. The boxes and crates in which they were shipped filled five average sized rooms at Columbia University. This is an indication of the extent to which the pupils voluntarily entered upon this type of self-activity.

3. The teachers state that the films increased the quality and quantity of children's reading. This opinion is confirmed by administrative officers of the school systems and in other instances by the school librarians. In many cases librarians reported that library facilities were not adequate to care for the increased library demands of the children involved in the experiment. The teachers stated that values growing out of this were the ability of the children to learn how properly to use reference books and how to select main points bearing on a definite topic; that they also acquired the ability to organize material in logical form.

4. The teachers are practically unanimous in saying that the films stimulate greater facility and freedom in discussion, and resulted in more extensive writing by the children than they had ever been able to secure without films. The two directors also gave testimony upon this particular point, and stated that during their years of teaching experience and observation of classroom practice, they have not observed such liveliness or such sustained discussion as in these classes.

5. The teachers state that there is a better correlation and interpretation of materials due in large part to the fact that the films develop greater immediate self-activity and promote longer and more vivid retension. In many instances children visited a local bakery, a dairy, a farm, or some industrial or commercial en-

terprise where they could see in actual operation scenes suggested in the films.

6. The teachers also testify that the films contribute to richness of material and accuracy; that the children get clearer information in many ways than they can get from reading; that many things which are difficult to understand from the printed page are clear in the film.

7. There is unanimous opinion that the films contribute to an ability to concentrate mental activities, to think more accurately, and to reason more soundly.

8. Likewise there is unanimous agreement that the films develop a marked improvement in the range and accuracy of vocabulary.

It is the overwhelming testimony of the teachers of the film group that the films made large contributions to the major objectives of classroom instruction. The directors of the experiment state that their own personal observations of the work in the schools of ten of the twelve cities confirm at every point the opinions expressed by the teachers.

The service which a film renders a teacher in the arrangement of her material and in the presentation of a recitation is a matter of major importance in classroom practice. The teachers of the film group are practically unanimous in stating that the films were a distinct advantage to them in making a thorough preparation for the classroom work. They testify that they were able to prepare a more logical presentation of a lesson with than without the film. It is their opinion that the film presents the basic elements of a lesson or a topic. In the selection of classroom material they were able to choose from a mass of available material which was most essentially related to the vital factors of the topic under consideration. They express the opinion that the film compel a teacher to conduct a more orderly and logical recitation, and that the film prevents her from digressing from the main points which should be clearly brought out.

In my address before your Lake Placid meeting in 1927, I stated that the experiment was undertaken in the belief that it would reveal the essential information necessary to the development of a sound program in Visual Instruction through the use of motion pictures. The outcomes of the experiment have amply justified that

belief. The report by Dr. Wood and Dr. Freeman is comprehensive and convincing, but considerations of time made it necessary to confine attention to questions of immediate interest. It is the opinion of those who have examined the materials derived from this experiment, that it affords valuable data for a number of additional research studies in education which will reveal still further the many advantages to be derived from the use of motion pictures of this type in the classroom.

New York was one of the twelve cities in which the experiment was conducted. It was under the general supervision of Dr. Straubenmuller, Associate Superintendent, and one of the best known and most highly respected school administrators of the country. Dr. Straubenmuller made a thorough and comprehensive study of the experiment and of the report submitted by Dr. Wood and Dr. Freeman, which he reported to the Board of Superintendents of New York. In his report he says:

"While there have been experiments which were controlled to an extent, your committee feels that no experiment has been so thoroughly conducted, so scientifically pursued; it is undoubtedly the outstanding report on this subject and will not be duplicated in its comprehensiveness for many years, if ever."

Dr. Straubenmuller further says, "Your committee, after careful study of the manuscript of the report about to be published, and from observation of the experiment as conducted in the schools of our city, believes that the motion picture can be successfully and profitably used, if the pictures are made specifically for instructional purposes and fit exactly into the course of study." This report was approved by the Board of Superintendents and adopted by the Board of Education.

I am gratified in closing this paper to offer this confirmatory judgment of the comprehensive and painstaking report of Dr. Wood and Dr. Freeman by such eminent authorities as Dr. Straubenmuller and his colleagues.

DISCUSSION

MR. BARRELL: First, the states in which this experiment was carried out. Were they northern states or scattered?

MR. FINEGAN: I did not give that information, as my paper was too long to get it thru within the prescribed time. The enterprise was organized in twelve cities, widely destributed thruout the United

States. These cities were Newton, Mass., Rochester, N. Y., New York City, Winston-Salem, N.C., Atlanta, Ga., Detroit, Mich., Chicago, Ill., Lincoln, Neb., Kansas City, Mo., Denver, Colo., Oakland, Calif., and San Diego, Calif. The Atlantic Coast, the Central West, the South, the Mountain States, and the Pacific Coast were represented in this experiment.

MR. BARRELL: Have any of the schools using this system actually adopted it?

MR. FINEGAN: This system was permanently adopted in all the centers in which it was carried out, except two, and one of these centers is a city which has been having financial trouble, and was not able to take it on.

MR. BARRELL: Is that 16 m/m film?

MR. FINEGAN: Yes. We take all pictures on standard and reduce to 16 m/m. This was used in experiment, and nothing else.

CHAIRMAN GAGE: Something like two years ago, Mr. Finegan began work on this experiment. I think the results of the experiment are of the greatest interest, and I believe there are other people in the room who might like to comment.

MR. BRIEFER: Was there one showing only of the film, or were there duplicate showings? Did the children grasp it from the first?

MR. FINEGAN: That was left to the discretion of the teacher. There was a difference of opinion among the teachers on this point. Some showed all the film first and then showed a unit of the film related to the particular recitation that was being considered at the time.

MR. O. A. ROSS: Tell us about the educators. Who prepared the films?

MR. FINEGAN: I had something to do with it myself. The Editor in charge was a man who was graduated from a Central Western college, entered upon the study of medicine and decided he preferred teaching, and began to teach. He was a teacher in an academy; a professor in college; took postgraduate work in Chicago University in science and philosophy; had experience as a professor of Economic Geography; gave lectures in Oxford and University of London; traveled in Europe; and had two years on the editorial staff of a publishing concern, in the development of a series of books on science. The others were all college or university graduates who had had about twelve years' experience in teaching in public schools

of this country. Some of them represented the West, and some the East.

MR. ROSENBERGER: Was the picture first shown, and did the discussion follow, or the reverse? What method was commonly used or found most effective?

MR. FINEGAN: In an enterprise of this kind, you must set up a common standard in grades, so there was a uniform period prescribed for instruction of thirty-five minutes. There was no direction as to the relative amount of time given to the film and to other instruction. We have found that an average of four to five periods were given a film. There were ten films on each course. About forty-five minutes were used in showing each film. The forty-five minutes which the children devoted to the study of that film were used by the other children in recitation work or receiving other instruction. struction, on the average about forty-five minutes.

MR. CARLYLE ELLIS: What was the length of the unit?

MR. FINEGAN: One unit might be five or twenty minutes.

MR. ELLIS: If I remember the list of subjects, you seemed to avoid biology and history. Why did you avoid history?

MR. FINEGAN: Before we began the development of the work relating to the experiment, Mr. Eastman called a conference of about twenty-five educators at Rochester, and in that conference, he asked them to specify the subjects most desirable for this enterprise. The subjects selected were the subjects chosen in that conference.

MR. ELLIS: Is it your experience that the Boards of Education like to have the subjects colored to meet their views and beliefs? You would not get far with evolution in Tennessee.

MR. FINEGAN: It seemed wise in an experiment of this type to avoid controversial questions.

MR. ROSENBERGER: Has it been considered to continue with these experiments in universities?

MR. FINEGAN: Do we intend to continue experiments? Yes. We shall experiment with every film which we make, and we should continue additional research in the many phases of this subject, as indicated in my paper.

THE STUDIO ELECTRICAL DEPARTMENT AND ITS RELATION TO PICTURE PRODUCTION

M. W. Palmer*

THE object of this paper as its title suggests is to give you some idea of the organization of the electrical department of a studio and its functions.

The electrical department is one of the larger departments into which studio work is divided. It comprises an electrical engineer who is in charge, a chief electrician who is in direct charge of the stage crews, a set-foreman for each production being produced in the studio, and a crew of men working under each set-foreman who handle the lighting on that particular production. Besides these men, there are generator room operators, refrigerating machine operators and maintenance and repair men. These last named men are not employed directly on the sets but function in connection with the productions going on in the studio.

As soon as a story is ready for production, and in most cases before the cast has been entirely selected, a copy of the scenario script is sent to the electrical as well as the other departments concerned in the making of the picture. This script is sent out in advance so that the department can be informed as to any special effects which have to be prepared in advance of the starting date such as lightning effects, miniature sets, storm scenes, or any special effects which might require specially selected equipment or apparatus. Preparations are immediately begun to provide the type of equipment necessary, so that all will be in readiness when production is started.

A study must also be made of the size of the sets to be used in the production so that a check up can be made as to the amount of lighting equipment required. If a sufficient amount of equipment is not available, arrangements must be made to purchase or rent the additional equipment needed, so that there will be no hold up from lack of equipment after the production starts. A careful check must also be made as to the maximum amount of electric current which will be used on the big sets, so that the amount of current needed can

* Paramount Famous Lasky Corp., Astoria, L. I., N. Y.

be provided. It is sometimes necessary to arrange for gasoline generator sets, and other auxiliary generating equipment, to be used on the days when the peak loads will come. This must also be arranged for in advance.

When a starting date has been decided on, and the first set is built, the electrical department must follow along with the carpenters working on the set and see that necessary platforms, scaffolds, etc., are provided to carry the lamps and the operators to handle them. A great deal of special construction which is never seen in the finished picture is necessary to provide means of supporting the lights and their operators. Each production brings a new set of conditions, and special construction is always necessary.

Certain standard equipment is used, such as spot light "jacks", which are slung over the tops of the set walls to support the overhead lamps; rolling platforms of various heights are also kept as part of the permanent equipment.

When the set is all ready to "shoot", and as the director is rehearsing his actors in the first scene, the fine points of the lighting are worked out by the cameraman and his set-electrician, as it is not until this time that the cameraman knows just where the action will be played in that particular set. Other details must be carefully worked out, such as night and day sequences. If there are to be night and day scenes in a particular set, of course different lighting must be used in each case. For instance we cannot have bright daylight shining in through the windows if the scene occurs at midnight.

As the action of the play progresses and constant changes have to be made, from long shot to semi-closeup and closeup and back again to long shot, radical changes in the lighting must be made. There must always be a sufficient amount of reserve equipment on hand so that if the cameraman suddenly decides that a different setup is desired, equipment is on hand to handle the new conditions.

While this set is being shot, the one which the company is to go to next is being prepared. The cameraman leaves the set on which he is shooting and during his spare moments gives his instructions as to the lighting of the new set. Thus we go on through the entire production which sometimes involves 20 to 30 sets, each of which must be "lighted", "shot" and "struck."

The studio electrical crew will consist of 50 to 125 men, according to the number of productions in progress and the size of the sets.

A studio will have three or four hundred different pieces of

lighting equipment which must be kept in perfect operating condition at all times, and the spare time of the men is occupied in caring for and checking up on this equipment. There are also wind machines, cables, switchboards, rigging equipment to be maintained and repaired. Everything must be kept up to the highest state of efficiency so the possibility of a breakdown is reduced to a minimum.

The personnel of the studio crew is carefully selected and only men with initiative and an active spirit of co-operation are assured of permanent positions. Each man in the crew can contribute something to the success of the production, and those who do take this active interest have their little share of pride when the production is a success.

In closing I might say a few words as to the value of the lighting equipment and its accessories used in motion picture production. The value of lamps alone in one studio unit will run from $75,000 to $100,000. The switchboard equipment, cables, generators, etc., which go along with this lighting equipment will run another $100,000; so that the electrical equipment of an up-to-date studio will run close to $250,000. New types of lighting equipment are constantly being introduced and are adopted by the studios as fast as they prove their adaptability to the work, which means there is a heavy depreciation cost; but as we are in such a fast-growing industry, I suppose that is to be expected.

DISCUSSION

MR. CADENES: When you have three or four companies working on one unit at one time, do you have one electrician in charge of all?

MR. PALMER: We have an electrician in charge of each company. Usually the cameraman has a favorite electrician, and he wants that man to work through with him.

MR. MANHEIMER: I would like to ask Mr. Palmer, in the working of the lighting for the various sets, how is the amount of light determined for that set, and who determines it? I would also like to ask what proportion of the arc and incandescent lamps are being used in the Paramount Studios, and what percentage will be used in the future?

MR. PALMER: In connection with the determination of the amount of light to be used on the set, the cameraman is the man who decides how much light should be on the set. We are having made some photo-electric cells to be taken on the set so as to tell how

much illumination is needed on the set. This will help the cameraman. For the past year we have used all incandescent equipment. We are going back to some of our arc lighting for reasons of efficiency. We do not get as much light on the set from 100 amperes in incandescents as we do from 100 amperes in arcs, and unless the incandescent men catch up, we will go back to arc lighting.

MR. ROSS: Are you using Cooper-Hewitt for arc lighting?

MR. PALMER: We have about 1,500, but are not using them.

MR. ROSENBERGER: Is there an advantage in using AC instead of DC?

MR. PALMER: I think possibly some of these incandescent lamp men can answer better than I can, but it does not seem to make any difference. Occasionally we use alternating current on our lamps. If used on incandescent lamps of over two kilowatts capacity, you do not notice any fluctuation in light, as the filament holds the heat.

MR. BARRELL: I want to ask what progress is made in silencing arc lights.

MR. PALMER: We cannot say at present. We are working on choke coil information from the Bell Telephone Labs. We are putting chokes in series with our arcs and can entirely eliminate the sound from a DC arc.

MR. BARRELL: Does that call for a new model in the arc light, or does the present model answer?

MR. PALMER: It can be applied to any present arc.

MR. CRABTREE: When we met in Hollywood last year, there was a symposium on incandescent lighting for studios. At that time, there were two criticisms of the incandescents: that it was impossible to secure with them sharply-modelled photographic effects; and that they produced too much heat on the set. Do these objections still hold?

MR. PALMER: One of the men who favored the incandescents spoke at that time of how much money could be saved from labor and current standpoint in use of incandescents, and I was very much interested in the subject at that time, as I am now; and I said, after he finished, that probably we could save money, but it would only be the interest on the amount we would have to pay out for refrigeration to keep the people cool, which we would have to put into our studio to take care of the heat from these lamps. The big objection is the amount of heat which they produce.

I do not think you get the same kind of photograph with incandescents that you do with arcs. Incandescents give a softer and possibly a more artistic photo but not as sharp.

MR. CADENAS: I would like to explain the lamps's soft effect. The lamp itself is satisfactory. I also want to say that in many cases where photography is very soft, that color corrections have not been made on the lenses to get the right effects with panchromatic film and Mazda lamps.

MR. BEGGS: The incandescent lamp has a filament larger and not as bright as an arc. It is necessary to use a larger focus reflector. That is probably the most important change in studio equipment for Mazda lamps. The lamps are hotter, for a lot of the radiant energy is heat, more so than in the arc. Several ways to overcome this have been suggested. Some are considering mounting these lamps on projectors behind water cells. This is not difficult where the actors need protection. After all, the big sales point of a Mazda is the convenience of it.

MR. EGELER: Lighting improvements, which have recently been made, show an average increase in efficiency of the lamps of 50%, and will greatly reduce the amount of heat.

MR. E. H. RICHARDSON: However, I know of one studio that has installed a first class air cooling plant. Other studios have ventilating systems. In most cases, cooling systems have been put in. We still have to fight this condition. Where we used that Broadway set again and again the entire complement of lighting was left on for long periods of time. The studio presently was opening the windows. However, it was interesting to note the intense illumination.

MR. PALMER: As far as killing the lights are concerned, the reason the lights are not killed is because the lamps, after being turned out, take five minutes to heat up when turned on again.

MR. ROSENBERGER: It seems to me that much current would be saved if many scenes were considered from the artistic point of view, and less light used. I have seen scenes where less lights were used, and the scenes were better. The art of the stage would be heightened.

MR. MANHEIMER: I think the reason for using so much light on the studio stage is the desire of the cameraman to get a sharp exposure and he depends on the laboratory to tone it out.

MR. PALMER: As far as I am concerned, the discussion is closed.

BULB CLEANSER FOR INCANDESCENT LAMPS

D. K. Wright* and C. E. Egeler**

THE history of incandescent lighting has been characterized by a succession of advances in the efficiency of light production. Through various steps in development from the early carbon lamps to the gas-filled MAZDA types of today, efficiency increases have come one after another. There have been major improvements in filament materials as when tantalum and tungsten were introduced, and minor changes which produced less spectacular increases. Neglecting the lower cost of electrical energy, and taking all sizes of lamps into consideration, the public receives over ten times as much light for the same power as it did when incandescent lighting was first introduced. The highest wattage lamps regularly used today give seventeen times as much light per watt as did the early carbon lamps. Electrical energy costs much less today than in past decades and lamp prices are but a fraction of what they once were. The effect of all these factors is that on the average, electric lighting costs but one-sixteenth as much as in 1890, and for the largest lamp the cost is only one-nineteenth.

It is most appropriate that this fiftieth anniversary of the successful development of the incandescent lamp by Thomas A. Edison —the Golden Jubilee of Light—should be the occasion of two other improvements in high wattage lamps of particular interest in motion picture production. They mark the greatest single advance since the gas-filled lamp. These improvements are the application of a practical cleaner for the inside of the bulbs and the use of a new treatment for the filament wire. They give a 30 per cent initial increase in light output, with less than half the previous depreciation in candlepower during life, or a total gain in average efficiency of about 45 per cent.

Bulb blackening has always been a problem in incandescent lamp design and requires particular attention on lamps in which the bulb area is small in relation to the wattage. When the filament is heated to incandescence it slowly evaporates and the vapor con-

* General Electric Company, Cleveland, Ohio.
** National Lamp Works of General Electric Company, Cleveland, Ohio.

denses on the inside surface of the bulb as tungsten oxide and tungsten nitride. Chemicals have long been used to reduce the moisture that may be present in a lamp and thus minimize the desposit of tungsten oxide which absorbs light, and therefore, reduces the light output of the lamp to an increasing extent during its life. As the bulb becomes more black, it absorbs both light and radiant heat, gets hotter, and the temperature may reach the point where the glass softens and devitrifies.

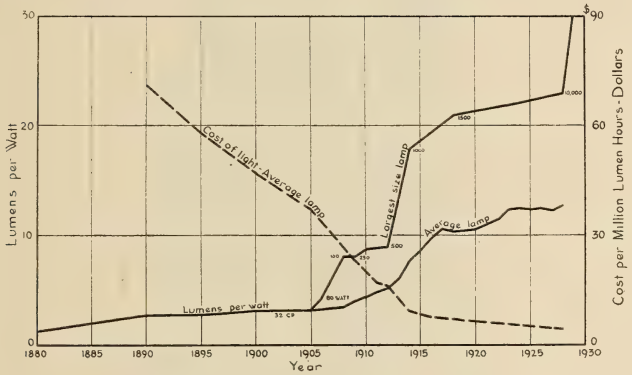

FIGURE 1. Progress in incandescent lamp efficiency and cost of light.

Most of you are familiar with the manner in which this feature of lamp design was taken care of in projector lamps used with the condensing lenses—how by the use of a tubular bulb the blackening is deposited in the cooler upper portions above the area where light is emitted in useful directions. There it causes a minimum light loss and the least heating. A recent development involved the use of a metal chimney on round bulb lamps of 30,000 and 50,000-watts rating which are always burned in the base-down position. Such, until recently, has been the trend of development to reduce bulb blackening and its effects.

Blackening has particularly been a limiting factor in the design of lamps of 2,000 watts and larger. The 5-kw. lamps, for example, have not as a rule been discarded due to a failure of the filament but to bulb blackening. If this blackening were reduced by increasing the bulb size, the cost of the lamp and reflecting equipment would become excessive and the units would be difficult to handle. With the rapidly increasing demand for the high wattage lamps required

for motion picture studio and aviation field lighting, experiments were started to develop a practical method of cleaning the inside of the lamp bulb, since the problem of reducing the blackening had already been the subject of many years' work, with little probability of immediate further improvement.

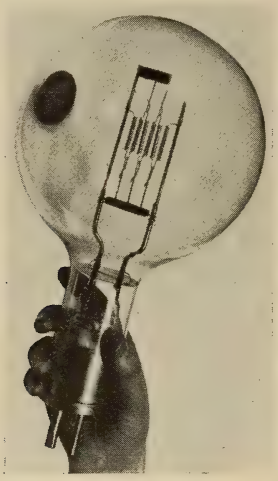

FIGURE 2. 5-kw. lamp with cleaning powder visible at bottom of bulb.

The first thought was to employ fine sand—the old practice in cleaning bottles—which proved unsuccessful since silicates were found to attack tungsten. Various high melting point oxides were tried out and different limitations encountered with each. The thought then occurred that it would be possible to use a material already in the lamp, such as tungsten. Tungsten metal powder was first tried—this coated the filament and bulb with certain undesirable results. Continued development produced a course grain crystalline structure metal which is a very good abrasive, does not cling to the bulb or filament, and which proved to be the answer to the problem. About a teaspoonful of this powder is put into the lamp. After the bulb has become blackened sufficiently to need cleaning, it is removed from the socket and by sliding the granular tungsten over the black desposit the bulb is quickly restored to a clear condition. The ease with which this is done always surprises, for few have realized how lightly the desposit settles on the bulb surface in a gas-filled lamp.

The effect on bulb-blackening in the use of this cleansing powder is shown by the photographs of Fig. 3. Two lamps are shown which were burned for identical periods. The left hand vertical column shows the marked and increasing blackening for a lamp without the tungsten powder, burned for successive one-fourth life intervals. The second column shows another lamp with the blackening which has accumulated at the end of each of the periods, and the third column the same lamp cleaned at the end of each period by the use of the powder. It will be noted that to the end of the last period the cleansing is so effective that the lamp bulb appears almost like new.

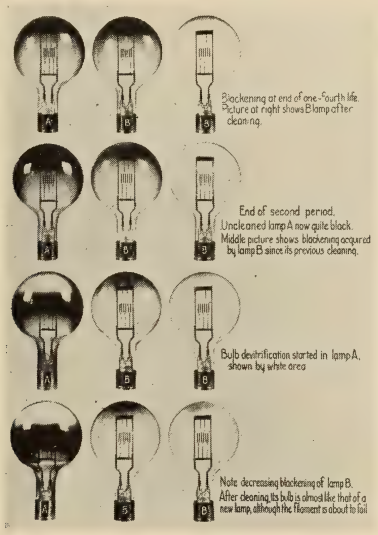
Blackening at end of one-fourth life. Picture at right shows B lamp after cleaning.
End of second period. Uncleaned lamp A now quite black. Middle picture shows blackening acquired by lamp B since its previous cleaning.
Bulb devitrification started in lamp A, shown by white area
Note decreasing blackening of lamp B. After cleaning, its bulb is almost like that of a new lamp, although the filament is about to fail

FIGURE 3. Bulb blackening for 5-kw. 115-volt G-64 bulb MAZDA lamps operating at 30 lumens per watt.

The effect on light output is shown by the curves of Fig. 4. Broken Curve A shows that at the end of the first 20-hour period, the blackening has decreased the light output of the lamp to 75 per cent of the initial value. Cleaning the lamp brings back the light output to 99 per cent. During the next period it drops to 82 per cent and in cleaning it is brought back to 96 per cent. At the end of the fourth burning period the light output has dropped to 83 per cent of the initial value; cleaning brings it back to 92 per cent from where it again decreased to 81 per cent at 100 hours' life. The final cleaning brought the light output back to 90 per cent of the

initial. The mean light output for this cleaning cycle is 88 per cent of the initial.

Curve B shows the candlepower maintenance for a lamp of the same initial light output but which is not cleaned during its life; the mean value here is only 61 per cent of the initial. Of course this lamp would not have been used this full life period since the light output has decreased to 40 per cent of the initial.

If the lamps are cleaned at intervals of less than 20 hours, the mean light output is of course greater than 88 per cent, approaching the limit of 95 per cent shown by Curve C of Fig. 4. In practice, cleaning at the end of 10 hours and 20 hours, and every 20 hours thereafter is suggested.

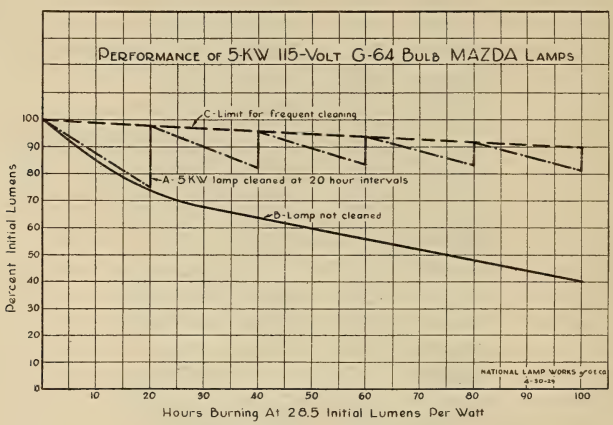
Performance of 5-KW 115-Volt G-64 Bulb MAZDA Lamps
C-Limit for frequent cleaning
A-5KW lamp cleaned at 20 hour intervals
B-Lamp not cleaned
Percent Initial Lumens
Hours Burning At 28.5 Initial Lumens Per Watt
National Lamp Works of G.E. Co.
4-30-29

Figure 4. Effect of cleaning on performance of 5 kw. lamp.

Now that blackening was no longer the limiting design factor, it was found possible to increase the filament temperatures, and therefore the efficiencies of the lamps, without sacrifice of useful life. In the case of the 5-kw. size, this increase in initial light output amounts to 30 per cent. When the much higher candlepower maintenance due to cleaning is added to this efficiency increase, it is found that for this wattage the mean light output can be increased 46 per cent—striking improvement of great advantage to the industry. Referring to Fig. 5, Curve A shows the performance of a lamp of the old construction and efficiency, with a lumen output depreciation to about 70 per cent of its initial value. Curve B shows the performance of a lamp of new construction with 30 per cent greater

initial output, and the high depreciation which occurs if the bulb is not cleaned. Curve C shows the performance for the lamp cleaned at the suggested periods, for which the average maintenance is 90 per cent of the initial, and 46 per cent greater than that of the old lamp shown by Curve A.

An interesting feature (shown by the photographs of Fig. 3) is that the blackening is greatest during the first operating period and that during later periods it is not so marked. This is principally due to the moisture liberated from the glass, which is mostly freed early and continues to only a very limited extent when the bulb

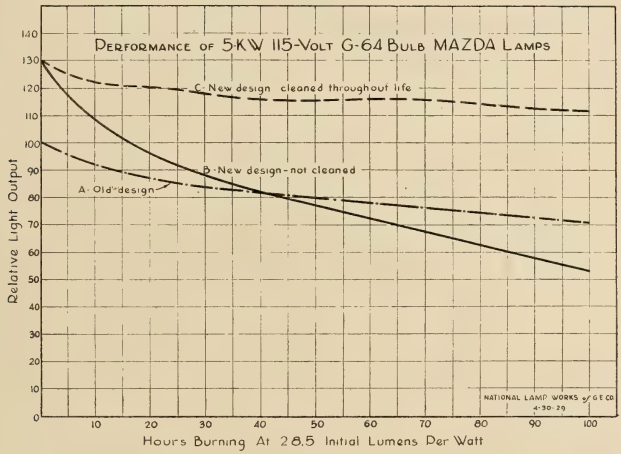
Performance of 5-KW 115-Volt G-64 Bulb MAZDA Lamps
C New design cleaned throughout life
B New design - not cleaned
A Old design
Relative Light Output
Hours Burning At 28.5 Initial Lumens Per Watt
National Lamp Works of G E Co
4-30-29

Figure 5. Relative performance of 5 kw. lamps of old and new designs.

temperatures are a little changed during the life of the lamp. Thus, after the early cleaning periods, the cleaning required is less.

Operation of the lamp filaments at higher temperatures is in itself no small accomplishment, for it required a solution of new problems. Filaments as formerly made would sag and distort under the more severe temperature conditions. The solution for these difficulties is a new heat treatment for the tungsten wire which enlarges the tungsten crystals and thus practically eliminates sagging and distortion. The 5-kw. lamps are now designed for an initial efficiency of 28.6 lumens per watt, whereas only 22.0 lumens per watt was possible previously. Recent work indicates that it will be possible to burn these lamps at 29 or even 30 lumens per watt.

Because of the higher efficiency the new lamps have less filament, hence smaller source dimensions than the old. This means control of beam within smaller limits. The reduction in the linear dimensions of the source is of the order of one-fifth.

Fewer equipments will be required. Moreover, it is possible to place them advantageously so as to secure improved lighting effects. Where higher intensities are desired, they can be readily obtained since more equipment can be installed in a given space.

Of greatest significance to the motion picture industry is the saving of many, many thousands of dollars in production expense annually, which the new developments make possible, through the reductions in lamp, energy and equipment costs.

Lamps of the new construction are now available in the 5- and 10-kw. sizes, used in motion picture studio lighting, and in certain other lamps used for other services.

DISCUSSION

MR. COFFMAN: Do I understand that the higher the wattage of the lamp the greater its efficiency?

MR. EGELER: Yes, that is true. The higher the wattage of the lamp, the greater the current, which means a larger filament wire is used; it can be operated at a higher temperature for a given life than the smaller diameter wire. Up to this time, the blackening has been a limiting feature in high wattage lamps.

MR. STRICKLER: I want to ask how the life of the lamps averages. Do they average one hundred hours, above, or below?

MR. EGELER: We know incandescent lamps have individual lives which are above and below the average. The life we assign to the lamps is the average figure, for these high wattage lamps, 100 hours. Our tests show average lives above, rather then below the design figure.

MR. LOVELAND: Will not the sagging of the filaments greatly facilitate the blackening of the lamps, especially pear shaped lamps?

MR. WRIGHT: Sagging of the filament would not have the effect of increase in blackening; on the contrary, as the filament sags, the temperature decreases, and the rate of evaporation also decreases.

MR. PALMER: Figuring on the average life of one hundred hours, what is the cost of the lamp per hour?

MR. EGELER: I must have a moment for computation.

MR. DEPUE: Are they going to put that cleaning material in smaller lamps?

MR. WRIGHT: We will probably go on down the line. Just what point will be reached, we do not know. I do not think it would be feasible to go further than the 500-watt lamps.

MR. BEGGS: To assure the best results with the least labor and at the lowest cost, it is necessary to select the best, and standardize it. This is especially true in the motion picture business where great strides have been made. Now is the time to standardize the incandescent lamps used in sound apparatus. I did not have time last week to prepare a paper, but I would like to read some recommendations the lamp manufacturers have to offer.

The lamp manufacturers propose the following lamps with the recommendations that existing equipments be arranged to use them where they are not already suitably designed, and that all new equipments be made to accommodate them.

1—Camera and Recorder Marker and Indicator lamps—Mazda lamp No. 41 (2.5 Volt T4 bulb miniature screw base Radio Panel)

2—Reproducer (Photocell exciter) lamp—10 Volt 7.5 Ampere T8 bulb S. C. bayonet cand. base, C6 filament reproducer lamp.

3—Indicator and turntable illuminator lamp, 10 watt 115 volt S11 bulb (clear) intermediate screw base sign and decorative lamp.

4—Recorder and Reproducer Signal and double Turntable illuminator lamp, 25 watt 115 volt S19 bulb (inside frost) medium screw base general lighting lamp.

5—Recorder lamp—5 volt 6 ampere S11 bulb S.C. bayonet cand. base C2 filament recorder lamp.

It is strongly urged that all designers obtain full details concerning these lamps before they proceed with their work. The lamp manufacturers will be delighted to cooperate.

MR. EGELER: For a large studio the lamp cost per hour is slightly above 80 cents for the 10 kw. size, and about 32 cents for the 5 kw. size.

MR. CRABTREE: I have no desire to argue against incandescent lamps. But one argument is the danger of the bulb breaking when making closeups. Have any means been taken to prevent splintering?

MR. EGELER: The danger of the lamps splintering is very small. Of course on those equipments which are used for close-ups, they should put on cover glasses. That is the simplest answer.

MR. MANHEIMER: In the larger type studio lamps, I would like to know what is the actual burning life, and what is the economical burning life?

MR. EGELER: These lamps have an average burning life of one hundred hours. The theoretical most economical burning life is probably somewhat greater, but there comes in the factor of mechanical breakage, and color quality of the light and the space limitations for the equipments are the governing factors.

MR. E. H. RICHARDSON: Is nothing being done to develop a lamp with a longer burning life?

MR. EGELER: We can design a lamp for practically any life, but for a given light output, increase in average life is obtained at the expense of increased wattage.

MR. RICHARDSON: We are still using some with the tip on the end. The actual losses in these lamps have been in only very exceptional cases from blackening. The losses in these lamps have been mostly thru handling and packing. Most of the damage done is in loosening the bases, and damage due to jars where the mechanical structure is broken down. Here is the answer to that. The lamp is actually better even after 100 hours than before. Moisture has gone, and all the oxygen left has been absorbed. When the lamp is cleaned it is a most excellent product.

MR. WRIGHT: It may be of interest to know that the idea of cleaning the inside of incandescent lamps is an old one. We find it was tried in connection with the old carbon lamp. I understand Mr. Roger Hill did some work on it about ten years ago in connection with the motion picture projection lamps. He suggested sand. I believe sand attacked the filament and caused early burn outs. Recently Mr. L. C. Porter brought to my attention the work done with the sand cleaner at that time. The development of a tungsten powder cleaner has successfully solved the problem. Along with this development of removing the blackening has come the development of an improved non-sag tungsten filament wire. These two developments have combined wonderfully to give us this large increase in efficiency.

MOTION PICTURE ACTIVITIES IN THE UNITED STATES ARMY

Lieutenant Colonel Walter E. Prosser*

THE first interest displayed by the United States Army in motion pictures was in the field which, at the time, it shared in common with the rest of the world, the field of amusement. During the early history of the motion picture, the Army was concerned solely with the entertainment value of pictures and motion picture shows were to be found in every Army post. Even under canvas in the field, the troops had picture shows. They were welcomed by officers and enlisted men alike. I doubt if there has ever been devised a method of entertainment that more perfectly meets the demand of the military for sane and wholesome recreation than the motion picture. In most commands, a bugle call announced the hour of pictures. In my experience only one other call awakened more general interest in the command—the one known to all soldiers as "Pay Day", announcing the presence of the paymaster in camp.

There is no record of the Army realizing the instructional value of film prior to the entry of the United States into the World War. This is easily explained.

The military arm of the country during the days I am discussing was a small, compact, highly trained body of regular soldiers. The most efficient method of instruction, that of actual practice, drill and maneuver, was in vogue. The results produced by this method were entirely satisfactory. There was no need for intensive high speed training of large bodies of untrained men, such as became imperative when once the World War broke upon us, and, therefore, no necessity existed for increasing the methods of instruction employed in the Army at that time.

The World War brought with it many problems for the United States Army. In a short time our small regular force of 165,000 grew to four million men. Military organizations of over a thousand men frequently included not more than one Regular Army officer. The training problem soon grew to tremendous size and importance.

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New methods of instruction were sought to help out. It was here that pictures first began to play a part in training the Army. Men learn more quickly by the eye than by the ear. There are more eye-minded people in this world than there are ear-minded. Army officers knew this principle and applied it by using motion pictures in the solution of the new training problem. So, under the stress of war, the first instructional motion picture made its appearance.

I believe the Army was the first agency of importance in the country to employ instructional pictures. The Signal Corps of the United States Army made its first contract for a training picture with the Lee Film Company of San Antonio, Texas, in the spring of 1917. The contract was signed April 5, 1917, and the United States declared war on Germany April 6, 1917. It is of interest to note in passing that John J. Pershing, then Major General and in charge of the Army on the Mexican Border, approved the contract. The pictures made, illustrated the activities of field signal units, and the immediate object for which they were made was the instruction of the Enlisted Reserve Corps of the Signal Corps, not the Regular Army soldier.

Other uses for pictures were soon discovered. We found our World War recruits lacking in a great many kinds of knowledge. They not only needed instruction in military drill, discipline and tactics, but required to be taught the simplest rules of bodily health and sanitation. It was necessary to find a means of quickly warning the thousands of men recently called from all walks of life to the colors of the more common dangers that beset the path of the young soldier. This means had to be one which "packed a punch." Lectures and exhortations were of little use in getting across this message. Here, again, the picture could tell the story plainer and more emphatically than any words. Its message was expressed in the universal language, that of the eye. So, motion pictures were introduced in our war-time camps and soon proved to be an effective instrument in quickly influencing and educating that great body of young men gathered under our Flag in many of the moral and physical problems that confronted our World War Army.

The Army found yet another use for pictures under the spur of war. The factories, foundries, mills laboratories, shipyards, camps, all that multitude of agencies connected with producing what we term munitions of war, likewise required speeding up in pro-

duction. Motion pictures did their bit here not only in providing recreation, but in assisting scientific investigation and making permanent records.

Three principal problems arose in connection with the tremendous photographic duty thrust upon the Signal Corps by the war. First, the Signal Corps faced the problem of securing competent photographers; second, it must procure proper equipment for these photographers; and, third, the organization and administration of this new force had to be provided. None of these problems was easy to solve. The question of securing competent, efficient personnel gradually solved itself as the war began to take in more and more of our young men. The problem of equipping this force was not so easy. A great deal of the photographic equipment secured was obtained by combing this country, and those parts of Europe where we could still purchase it, for all types of photographic apparatus. The organization of our photographic force never did reach a satisfactory point. As a result of this, the active employment of our photographers in the field left much to be desired. Of some World War units we secured a large quantity of motion picture film; of others, some of the most active and interesting from an historical standpoint, we have only a small amount. These lessons have not been forgotten. Our present day plans and organization will prevent a similar situation arising again.

Out of the experiences of the World War grew the present peace-time motion picture organization of the Army. Three branches of the Army now participate in control of its picture activities, each operating a separate and distinct service. In the field of the producer are found the Signal Corps and the Air Corps. The Signal Corps produces all ground pictures while the Air Corps is charged with the making of aerial pictures. The Adjutant General's Department is the exhibitor agency of the War Department.

This latter agency is perhaps best known to the motion picture industry because it leases commercial pictures and screens them in Army motion picture theaters. It plays an important rôle in building up Army morale and in assisting in the maintenance of good order and discipline on Army posts. It provides our young soldier with a place to spend his evenings and gives him as good entertainment as can be found on Broadway at a very nominal charge. There are 105 theaters in the Army circuit. Only 20 of these serve a popula-

tion of 1,000 or more. The remainder serve populations that vary from 900 down to 33. The smallest posts are the most isolated and consequently have the greatest need for entertainment. Of course, the smaller posts operate at a loss. However, the entire service is profitable and it has been possible, from the returns, to build new theaters at four posts within the last year. The Army Motion Picture Service is operated by the Adjutant General's Department and has its home office in the State, War and Navy Building in Washington, D.C. At the present time it has not installed talking pictures but I understand that this problem is now under consideration and in a short time talking pictures will be placed in some of the larger Army theaters.

The Signal Corps is the largest motion picture producing agency of the War Department. It also maintains the principal motion picture files of the War Department. These files are made up of some six million feet of motion picture negative and positive, which are kept in a specially constructed fireproof vault at the Army War College, Washington, D.C. These motion pictures come principally from two sources, the World War and current domestic events in which the War Department is interested. We have about 750,000 feet of World War negative of our Army in France, and 450,000 feet of negative of current historical events in which the Army is concerned. The remainder of the six million feet is composed of duplicate negatives of all the original war time negative and a great deal of the present day current historical negative, and positive prints of both our war time and domestic negative.

The care of this large quantity of film has been a burden to those entrusted with it. Up to this time we have lost no negative from deterioration, but we have had losses of our positive. We are attempting to safeguard this invaluable record of our country's history to the best of our ability. We regularly remove it, unroll it, inspect it, clean it, then reroll it and restore it to the film containers. This seems to operate very satisfactorily in preserving the film. An investigation of the losses in the positive film revealed that probably these losses were due to improper fixing and washing when the prints were made.

The war scenes in our files are of great interest to the public. This interest is displayed by all classes of our people but it is centered in patriotic societies, schools, churches, civic societies and kindred agencies. The War Department feels that the public has a right to

see and acquire these pictures. Provision for this has been made, first, by sale of positive prints of our war time negative, and second, by the loan of prints to responsible parties for exhibition according to a definite War Department policy. There is a constantly growing demand for the loan service. To meet the demand we have compiled a great many pictures. These pictures not only cover the field of the World War but deal with current military history of our Army. Typical of the military pictures I might cite, "Flashes of Action", a war time picture which is well described by its title. In addition to this we have pictorial motion picture histories of most of the divisions participating in the World War. Of the domestic pictures the Mississippi Flood of 1927, the Burial of the Unknown Soldier, and the Inauguration of President Hoover as typical of this group have proven popular.

I have already mentioned that the Army entered the motion picture instructional field in 1917. It is still in this field. During the war, sixty-two training films were produced in addition to a large number of pictures which were used for instructional purposes other than training soldiers. However, I will devote myself to the training films, as the history of these is better defined than the pictures made for propaganda purposes and for technical use in factories, laboratories, etc. The training films had just been completed and were coming into wide use when the war ended and the demobilization of our huge World War Army and the reorganization of our Regular Army absorbed the complete attention of military authorities. Consequently very little thought was given to the employment of screen educational methods in Army training in the period immediately following the war. However, in the reorganization of the Regular Army, which had been swallowed up in our huge World War Army, there was created a reserve force and provision was made for a large group of Regular Army officers, who were to act as instructors of this reserve. From these officers who were facing a difficult problem, came calls for help in instructing the units under their charge. This demand revived study by the War Department of the motion picture as an instrument of training, so once more the screen began to receive attention as an auxiliary means of training particularly suited to the Army Reserve units. By motion pictures, perhaps better than any other way, was it possible to coordinate Army training and impart unified, systematic instruction to reserve units in an entertaining way.

This rebirth of interest in the subject of motion picture film as an agent of instruction has brought about several important developments in motion picture activities in the United States Army. One of the most recent and important of these was the organization of a special War Department committee to study the whole question of visual education in the United States Army and report thereon to the Secretary of War. At the end of the three months, which was spent in examining all types of instructional films which could be gotten together by the Signal Corps and making a careful research into all available matter bearing on the subject, the committee brought out a report which strongly approved of instruction in the Army of the United States by means of motion pictures. A majority of the sixty-two training pictures which had been studied carefully were recommended to be discarded as being old fashioned and unsatisfactory due to many changes which have occurred since the period of the World War in uniform, equipment and training doctrine. The committee suggested that no time be lost in replacing these pictures with modern films carefully designed to attract the attention of the recruit, hold it and guide it in the proper paths of instruction. The report outlined a program of production of silent pictures and recommended to the Secretary of War that the program be undertaken at once. It also approved the inclusion of the talking picture in the Army instructional program and recommended that the Chief Signal Officer be granted funds for experimental development of talking instructional pictures for the Army.

The Signal Corps has proved to its own satisfaction that with the training film it is practicable to entertain and instruct at the same time. The need for two qualities has gradually resulted in the adoption of some rules of construction in Army films which we regard as basic. They are as follows: the subject matter must be introduced in an entertaining manner; the film must be short—one reel is the ideal; the film must be so designed as to eliminate the trivial and unimportant details; it should not attempt to cover more than six important points; the entire subject must be illustrated graphically and pleasingly throughout. We would rather drive home a few points and fix these securely in the memories of our officers and soldiers than touch upon a large number of issues in a film of great length and obscurity.

Many years ago, a certain wise man said to his sovereign, "Sire, there is no royal road to learning." It is the privilege of the

speaker to challenge the present day accuracy of this statement, which has been imparted to hopeful youngsters by grim faced schoolmasters in every town and city in this country. I believe that we have discovered a key to easy instruction and a royal road to learning in the motion picture instructional film.

I will now refer briefly to a phase of the Army's problem in which this Convention, perhaps, has more interest than in others; that is, the one of proper photographic equipment for military purposes. In this connection there is an important factor to be borne in mind. The Army makes air pictures as well as ground pictures. The ground pictures are made at present by the Signal Corps, while the duty of making air pictures has been transferred from the Signal Corps to the Air Corps.

The problem faced by the Signal Corps calls usually for the type of equipment developed by the motion picture industry for use in the production of news reel subjects. Very little Signal Corps work is performed in a studio. It is, as a rule, out of doors work. The motion picture industry, as it develops new and better types of supplies and equipment for news reels is, therefore, carrying forward the necessary research and development work required by the Signal Corps for the proper types of supplies and equipment for its peace and war time forces. We do not need special types of equipment such as are needed, for example, in the work of the Air Corps. On this branch of the Army has fallen a burden of development of special types of equipment to fit into and function satisfactorily from airplanes in flight. The Air Corps was the first in its field in this country, so originally it did not receive much help in development and research work from outside sources. Much of our Air Corps development work has been in the improvement of types of still cameras for use from airplanes. However, some attention has been given to the emplacement of motion picture cameras in airplanes. At the present time, motion picture cameras are fitted on to the machine gun racks by a special mount contrived by the Air Corps. This permits fairly free manipulation of the camera.

The problem immediately confronting our Air Corps is that of rapid development and printing in the air. The ideal is to make a picture and deliver a print upon landing. This is not difficult for still pictures and it has been done in eight minutes. Up to the present time it has not been attempted with motion pictures, al-

though there is a military need which could be very satisfactorily solved by a motion picture taken in the air, developed and dropped to a headquarters where it could be projected at once and thus give the commander or his staff a graphic representation of country in advance of their troops. There has been some talk of television being used exactly in this manner. The commander, always several miles in the rear of his most advanced line of scouts, must rely entirely upon maps for accurate knowledge of the country into which his force may be penetrating. Sometimes the maps are faulty or absent altogether. If a practicable system could be devised which would permit an airplane to fly far in advance, spying out the country and transmitting motion pictures of it to a commander many miles in the rear, certainly the operations of military forces so equipped would be made much easier and safer.

In closing, I wish to state that it is a pleasure to me to acknowledge my gratitude for the opportunity to present to this influential body of scientists a brief statement of the activities of the Army in the field of motion pictures. The Society of Motion Picture Engineers, in my opinion, is performing a distinct and valuable public service and it well deserves the increasing regard in which it is held by those connected with the great motion picture industry.

DISCUSSION

Mr. Crabtree: In connection with the preservation of film, there are two aspects of the problem, namely:

(a) Prevention of decomposition of the film; and

(b) The protection of the film in the case of an external or internal fire.

The rate of decomposition of nitrocellulose is dependent almost entirely on the temperature at which the film is stored. Traces of impurities such as exhausted fixing bath not washed out of the film will tend to accelerate the decomposition, but the important thing to remember is to keep the film cool. In Washington the summer temperature averages around 80° F. so it is imperative that the Government cool the film vaults if they expect to have any records fifty years from today. The image on positive film deteriorates more quickly than that on negative because the positive image is finer grained and more readily attacked by oxides of nitrogen which are products of decomposition of the film base.

With regard to protection of the film in case of fire, in the case of valuable negatives, if for any reason a fire should start in one portion of the vault it is desirable that it should not travel to the other rolls, and the best way of protecting the film is to store it in one thousand foot rolls in individual compartments each one being connected to a flue and each compartment being insulated from the other.

Mr. Briefer: May I suggest that in the case of hermetically sealed film the decomposition is likely to be greater than in a container slightly aërated.

Mr. Crabtree: I think that is so, and it is bad practice to seal film in hermetically sealed containers. The film should be examined periodically and should be stored in loose covered containers. We think that a non-metallic container, such as fiber, is probably best because there is no chance of rusting of the metal; and, secondly, fiber or wood is heat-insulated, so that if one part of the film catches fire, the adjacent film will not catch fire as result of heat induction.

Major Prosser: You will remember that I mentioned we had a specially constructed vault. It meets most of the requirements brought out by Mr. Crabtree except one: we have no cooling system. We don't store the film in hermetically sealed containers.

SOME PROPERTIES OF FIXING BATHS*

J. I. Crabtree and H. A. Hartt

OF THE various types of fixing baths available, the potassium alum acetic-acid-sulfite fixing bath is employed to the greatest extent in modern motion picture film laboratories. Fixing baths containing chrome alum and, to a lesser extent, formaldehyde are also employed, but a description of the properties of such baths will be reserved for a future communication.

So far as is known, A. Lainer[1] was the first to suggest the addition of alum and sodium sulfite to a solution of hypo for fixing purposes but such a bath sludged very readily on the addition of developer. The authors have not been able to establish who was the first to suggest the addition of a weak acid to such an alum-sulfite mixture.

Although acid-hardening fixing baths have been extensively employed during the past thirty years, very little has been known regarding the precise effect of varying the proportion of the constituent chemicals or of the effect of use on their properties. It is the purpose of this paper to present some of the results of extensive research on the subject during the past few years in the Research Laboratories of the Eastman Kodak Company.

I. Requirements for a Satisfactory Fixing Bath

A satisfactory fixing bath must fulfill the following requirements:

(a) It should dissolve the silver halide emulsion on the film with sufficient rapidity and continue to do so throughout its life, without staining the film.

(b) Even at summer temperatures, during its life the bath should not precipitate sulfur. If film is fixed in a bath which is precipitating sulfur, more or less colloidal sulfur will be precipitated in the gelatin film which cannot be removed by washing. The sulfur will then combine with the silver image causing fading.[2]

(c) During its useful life, the bath should not precipitate

* Communication No. 396 from the Kodak Research Laboratories, Rochester, N.Y.

aluminum sulfite. This precipitate forms as a result of the reaction between the alum and the sulfite when the acid in the fixing bath becomes neutralized by the alkaline developer carried in by the film.

It has been shown by Sheppard and Ballard[3] that this precipitate consists of basic aluminium sulfite, the ratio of sulfurous acid to alumina varying according to the conditions of precipitation. Throughout this paper the precipitate will be termed "aluminium sulfite."

(d) The bath should not produce blisters in the gelatin coating of the film. If the bath is too acid, on the addition of developer the formation of carbon dioxide gas proceeds too rapidly and gas pockets are apt to form within the gelatin layer which finally break causing blisters.

(e) The degree of hardening of the fixed-out gelatin film should be satisfactory. Hardening of the film, however, is not necessary, provided the gelatin coating of the film does not swell excessively during processing so that it can be handled and dried satisfactorily.

Hardening primarily retards the swelling of the gelatin coating so that the film can be dried faster. In the case of unswollen and hardened film there is a minimum of water present in the film to be evaporated, while a higher temperature of the drying air can be employed without danger of softening or melting the gelatin coating. In case the film is handled by the rack and tank system,[4] the gelatin coating of unhardened film is apt to be damaged during wiping or squeegeeing previous to drying so that hardening is usually desirable.

The addition of developer to the fixing bath also has a decided effect on the hardening properties of the bath. Therefore, the bath should be so compounded as to maintain as nearly uniform hardening as possible throughout its life in spite of the gradual accumulation of developer carried over by the film.

(f) The cost of the bath in terms of the quantity of film fixed in it should be as low as possible.

II. Classification of Fixing Baths

Two essential types of fixing baths are in common use, namely (1) non-hardening fixing baths: (a) plain hypo (b) acid hypo; and (2) acid-hardening fixing baths.

1. Non-hardening Fixing Baths

A plain solution of hypo is quite satisfactory for fixing purposes provided little or no developer is carried over to it by the films. It is therefore necessary either to wash the film thoroughly after developing and before fixing which is usually impractical, or to use an acid stop or rinse bath. In such a case, some sodium sulfite must be added to the hypo to prevent sulfurization by the acid carried over by the films from the stop bath.

Many motion picture laboratories employ non-hardening fixing baths with their processing machines. A satisfactory formula is as follows:

	Metric	*Avoirdupois*
Hypo	250 grams	100 lbs.
Sodium sulfite (desiccated)	10 grams	4 lbs.
Sodium bisulfite	25 grams	10 lbs.
Water to make	1 liter	50 gals.

The function of the bisulfite is to neutralize the sodium carbonate in the developer carried over by the films while the sodium sulfite serves to prevent possible sulfurization in hot weather. It is necessary to maintain the acidity of the bath either by allowing a continuous stream of sodium bisulfite solution to flow into the bath, or by adding a definite volume of a stock solution at intervals. The precise quantity to add depends on the alkalinity of the developer, the degree of rinsing between developing and fixing, and the quantity of film processed, but this can be determined easily by titrating a small quantity of the fixing bath with alkali at intervals to ascertain the loss in acidity.

An alternative method of maintaining the acidity is to pass sulfur dioxide gas into the fixing bath either continuously or intermittently through a perforated hard rubber tube leading to the bottom of the tank. There is little to choose between sulfur dioxide gas or a sodium bisulfite solution as regards efficiency but there is a danger of contaminating the darkroom atmosphere with the objectionable sulfur dioxide gas if an excess of gas is accidentally passed into the solution.

2. Acid Hardening Fixing Baths

An acid hardening fixing bath contains the following ingredients: (a), a silver halide solvent (b), an anti-staining agent (c), a preservative or sulfurization inhibitor (d), a hardening agent.

(a) Although many solvents of silver halides are available, the most satisfactory for fixing purposes are sodium and ammonium thiosulfate. A solution of ammonium thiosulfate of a given concentration fixes more rapidly than a corresponding solution of sodium thiosulfate[5] but ammonium thiosulfate is more expensive and commercial grades are apt to contain free sulfur. For most purposes sodium thiosulfate fixes sufficiently rapidly and is entirely satisfactory.

(b) Practically any acid will function as an anti-staining agent because it has merely to neutralize the alkali in the developer carried over by the films and thereby retard oxidation of the developing agent. Organic acids such as citric, tartaric, oxalic, lactic, malic, maleic, and acetic, are more suitable than the inorganic acids because they are less dissociated and therefore have a correspondingly less tendency to precipitate sulfur from the hypo. Practically all of the solid organic acids yield with aluminium salts, complex aluminium ions which are not effective hardening agents.[6] Acetic acid has been found to be the most generally efficient acid for use in fixing baths but much is still to be desired from the standpoint of a perfect acid for this purpose.

Of the acid salts, sodium bisulfite and potassium metabisulfite are the most generally used but they are not suitable for compounding a hardening fixing bath containing alum because the reserve acidity of these salts is not sufficient to prevent the precipitation of aluminium sulfite on the addition of alkali.

(c) It is imperative when compounding an acid fixing bath to have a quantity of free acid present in order to prevent discoloration of the bath by developer oxidation products and also to prevent the precipitation of the hardening agents by the alkali in the developer. This free acid tends to cause the precipitation of sulfur from the hypo especially at temperatures above 70° F. It is therefore necessary to add some substance which will prevent the precipitation of sulfur without impairing the anti-staining properties of the acid.

Two types of substances act in this manner. The first of these consists of the alkaline sulfites of which sodium sulfite is the most common. Since hypo decomposes in the presence of acid to form sodium sulfite and sulfur, it is considered that the addition of sulfite to an acid fixing bath retards the decomposition of the hypo

because it tends to reverse the action by virtue of its mass action.

The second type of preservative consists of the alkali salts of organic acids which are commonly referred to as "buffer salts" and of which sodium acetate is a typical example. The effect of this type of substance is to buffer or reduce the hydrogen ion concentration of the acid employed below the limits at which sulfur is precipitated from hypo by acids.

(d) The hardening of gelatin may either be temporary or permanent. Temporary hardening agents raise the melting point and prevent the swelling of gelatin only while the gelatin is in contact with the hardening solution. A concentrated solution of sodium sulfate is a typical temporary hardener.[7] The hardening produced by such substances is reversible, that is, the gelatin will subsequently absorb water and swell. Such hardeners will not be discussed because their application is limited to tropical development when the temperature of the various photographic solutions is above 75° F.

Permanent hardening is characterized by a reduced absorption of water (swelling) by the gelatin during subsequent washing. Various materials may be used for permanently hardening gelatin such as formalin, quinone, tannin, organic developer oxidation products, and certain inorganic compounds. Formalin, quinone, and developer oxidation products harden gelatin only in alkaline or neutral solutions and their application is therefore limited to use in developers or to the hardening of completely washed film.

Of the inorganic compounds, the salts of iron, chromium and aluminium exert the most powerful hardening action on gelatin. Salts of aluminium are perhaps the most satisfactory hardeners because they are colorless, readily soluble in water, and do not form colored compounds with the common developing agents either in acid or alkaline solutions, while they give satisfactory hardening provided the wash water is not above 75° to 80° F. Aluminium chloride tends to hydrolyze when dissolved in water, forming a white precipitate of aluminium hydroxide but the double salts of aluminium sulfate with sodium or potassium sulfate called *alums* form a clear solution and are therefore to be preferred. Sodium and potassium alum are equally efficient but with the ammonium alum an evolution of ammonia takes place after the fixing bath becomes alkaline and this tends to produce dichroic fog.[2]

III. Standard Tests for Determining the Properties of Fixing Baths

To date very few methods of representing the properties of a fixing bath in numerical terms have been published. The following tests, however, in no way give absolute measurements but they have proved satisfactory as a means of comparing the various formulas examined.

1. Time of Fixation. The time to clear Eastman negative motion picture panchromatic film when viewed against a black background was taken as a measure of the time of fixation. In order to maintain uniformity the film was immersed directly in the fixing bath and not previously developed in order to eliminate any error caused by swelling, which might influence the rate of diffusion of the hypo into the gelatin film and thereby affect the rate of fixation.

2. Acidity. One hundred cubic centimeter portions of the fixing bath were titrated with MQ_{25}* developer using phenolphthalein as an indicator. The results are expressed as the number of cubic centimeters of developer required to neutralize 100 c.c. of fixing bath.

3. Sulfurization Life. The time required for the average acid fixing bath to precipitate sulfur at ordinary temperatures (65° to 70° F.) is relatively long, so that in order to increase the rate of precipitation of sulfur and reduce the time required for the experiments, samples of the fixing bath were kept in glass-stoppered bottles at 110° to 115° F. and the time noted for the first visible

Elon	1.25 grams
Hydroquinone	3.75 grams
Sodium sulfite	75.00 grams
Sodium carbonate	25.00 grams
Potassium bromide	1.5 grams
Water to	1.5 liter

turbidity. It was considered that a bath which was not stable under these conditions for one-half day was highly undesirable, whereas if the bath remained clear for three days at 110° to 115° F it was found to remain clear for about one month at normal temperatures and therefore would be quite satsfactory for use at ordinary temperatures.

* Note: (Formula of MQ_{25} Developer)

4. Hardening. The relative hardening produced by a given fixing bath was determined as the temperature at which the emulsion left the support after treatment in the following standard manner:

Strips of Eastman motion picture positive film 3/8 inch by 5 inches were exposed so as to produce three densities at one end of the strip, ranging from approximately 0.5 to 2.5 after development. These strips were developed in MQ_{25} diluted 1:1 for 2 minutes, rinsed 30 seconds, fixed 5 minutes in the fixing bath to be tested, and washed 15 minutes in running water. The temperature of the solutions up to this point was maintained between the limits of 65° to 70° F. The film was then placed on a wooden frame which was immersed in a beaker containing 750 c.c. of water at 70° F. The temperature of the water in the beaker was raised from 8° to 10° F. per minute and the temperature at which the gelatin emulsion left the support was taken as the melting point or a relative measure of the hardening produced by the fixing bath. The apparatus as used is illustrated in Fig. 1. The temperature at which the gelatin

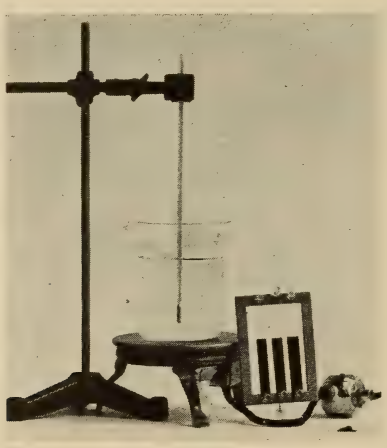

FIGURE 1. Apparatus for determining the melting point of the gelatin coating on motion picture film.

emulsion reticulated was not recorded after the first few experiments because it was found that this value is related to the melting point by a definite ratio. The degree of hardening produced depends on a large number of factors all of which must be maintained constant if consistent results are to be obtained. Some of these factors may be tabulated as follows:

1. Nature of emulsion used.
2. Alkalinity of the developer and time of development.
3. Composition of rinse or stop bath.
4. Time in rinse or stop bath.
5. Concentration and relative composition of fixing bath.
6. Time during which the films remain in fixing bath.
7. Age of fixing bath after mixing and previous to use.
8. Rate or agitation of film in the rinse and fixing baths.
9. Time of washing.
10. Temperature of the various solutions.

In the above tests a standard developer and emulsion was used throughout, and the time of rinsing, fixing, and washing; the degree of agitation during developing, rinsing, fixing, and washing; and the temperature of all solutions was maintained constant. At the outset, the effect of the alkali retained by the gelatin on the hardening produced by the fixing bath was not considered but in all of the cases studied the quantity of alkali retained by the film was held constant so as not to affect the results.

Later experiments showed that the temperature and age of a fresh fixing bath had some effect on the hardening properties even though the bath had not been used. In the experiments the baths were prepared within at least an hour previous to the tests and maintained at a uniform temperature.

The rate of increase in temperature of the bath in which the melting point tests were made affected the determined melting point; that is, the greater the rate of temperature increase, the higher was the apparent melting point. The degree of agitation during the melting point determination materially affected the results. Mechanical agitation was at first tried but this was found to produce inconsistent results over a series of test strips. It was decided that uniform, vertical, hand agitation was the most desirable the frame being moved up and down twice each minute. It was observed that flashed portions of the test strips melted at the same temperature as the gelatin which contained no silver.

5. Developer Capacity. (a) The quantity of MQ_{25} which could be added to a fixing bath before the precipitation of aluminium sulfite occurred was considered as its useful developer life or capacity. Although the addition of a given quantity of developer may not produce a precipitate immediately at normal temperatures, the bath will frequently precipitate a considerable quantity of aluminium sulfite after standing for a period of several days. The

developer life tests were made by placing samples of the fixing bath containing varying quantities of developer in a hot room at 110° to 115° F. and noticing the quantity of developer required to cause precipitation of aluminium sulfite. For practical purposes the developer capacity was recorded at both 70° F. and 110° F.

(b) In order to test the effect of the addition of developer as carried over by films or prints on the hardening properties of a fixing bath, varying quantities of MQ_{25} were added to the fixing bath and hardening tests made on these samples as outlined previously.

All of the properties of a fixing bath, other than the rate of fixation, are so closely related to one another that it is impossible to discuss one without considering its correlated influence on the other properties of the bath, and for this reason the experiments on the various properties of the fixing bath as outlined above will be discussed under the one heading of "Hardening Action."

IV. The Time of Fixation of Hypo Baths

The chemistry of the processes of the dissolving of silver halides by sodium thiosulfate (hypo) is generally considered to be as follows: The silver halides are probably dissolved in three steps, namely (1) a white insoluble silver thiosulfate is first formed which is further acted upon by the hypo with the formation of (2); a colorless and soluble silver mono-sodium thiosulfate and this reacts again with the hypo forming (3), a water soluble silver di-sodium thiosulfate. The following equations represent the probable chemical reactions involved in the case of silver bromide:

(1) $2\ AgBr + Na_2S_2O_3 = 2\ NaBr + Ag_2S_2O_3$
Silver thiosulfate

(2) $Ag_2S_2O_3 + Na_2S_2O_3 = Ag_2S_2O_3 \cdot Na_2S_2O_3$
Silver mono-sodium thiosulfate

(3) $Ag_2S_2O_3 \cdot Na_2S_2O_3 + Na_2S_2O_3 = Ag_2S_2O_3 \cdot 2\ Na_2S_2O_3$
Silver disodium thiosulfate

In recent years it has been questioned whether a film which is just cleared is completely fixed or whether the film should be allowed to remain in the fixing bath for double the time required to clear. Experiments by Bullock[8], and Lumière and Seyewetz[9] indicate that a just cleared film is completely fixed and experiments by the authors have confirmed this observation.

The time required for fixation of any emulsion depends on several factors as follows:

(1) The nature and thickness of the emulsion.
(2) The nature and degree of exhaustion of the fixing bath.
(3) The temperature of the fixing bath.
(4) The degree of agitation of the film.

(1) In general, coarse-grained emulsions fix much more slowly than those composed of finer grains. For example, under any given conditions Eastman motion picture positive film fixes in about one-fifth the time required for Eastman negative motion picture panchromatic film. A thickly coated emulsion obviously fixes more slowly than one of less thickness.

(2) The times of fixation for various concentrations of sodium thiosulfate at 55° F., 65° F., and 75° F. for Eastman motion picture positive and negative panchromatic film are shown in Fig. 2. The

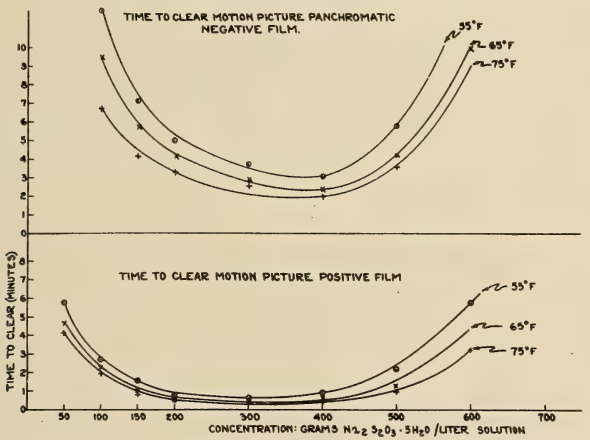

FIGURE 2. Curves showing the time to clear Eastman motion picture positive and negative film in hypo solutions of various concentrations at different temperatures.

negative film fixes most rapidly in a 40% solution which corresponds with the results of Piper[10] with Lumière film, while with Eastman positive motion picture film a 30% solution gives the most rapid fixation.

Some workers have contended that the hardening of a gelatin film does not affect the rate of fixation while others maintain that it does. Sheppard and Mees[11] found that formalin hardening does

not affect the time of fixation and state that in the case of hardened film which does not melt at 212° F. as compared with a film melting at 105° F., the time of fixation is the same in both cases. Experiments by the authors have indicated that although an excessive quantity of the hardened constituents retards fixation, for all practical purposes when using normal hardening baths with motion picture film, the hardener does not materially affect the time of fixation.

Strauss[12] and Lehmann and Busch[13] have observed that the accumulation of potassium iodide in a fixing bath used for fixing bromo-iodide emulsions has a considerable retarding effect on the rate of fixation. Experiments by Crabtree and Ross[14] indicate that the addition of 3 grams per liter of potassium iodide to a 30% hypo solution doubles the time to clear a negative emulsion at 70° F.

(3) The effect of temperature on the time of fixation is likewise shown in Fig. 2. With positive motion picture film an increase in temperature from 55° to 75° F. changes the time of fixation from 50 seconds to 30 seconds in a 30% hypo solution, while with negative film the same temperature change alters the time of fixation from 3 to 2 minutes in a 40% hypo solution. For maximum efficiency it is therefore necessary to maintain the temperature of the fixing bath not lower than 60° F.

(4) The effect of agitation on the rate of fixation is shown in the following table.

TABLE I

Effect of Agitation on the Time to Clear at 65° F.

Hypo Conc.	*Nature of Film*	*No Agitation*	*Agitation every 30 sec.*	*Continuous Agitation*	*Brush Treatment*
35%*	Eastman Panchromatic Negative	120 sec.	120 sec.	105 sec.	90 sec.
35%	Eastman Motion Picture Positive	35 sec.		35 sec.	30 sec.
10%	Eastman Motion Picture Positive	150 sec.	120 sec.	90 sec.	75 sec.

* Crystalline hypo was used. A 35% solution was prepared by dissolving 35 grams in water and then adding water to make 100 c.c. of solution.

It is seen that with motion picture negative film a very thorough renewal of the fixing bath at the surface of the film by brushing causes the emulsion to clear in 90 seconds at 65° F. as compared with

120 seconds with no agitation in a 35% hypo solution. Conditions of agitation analogous to those produced by brushing rarely exist in practice.

With positive motion picture film agitation has little effect under the same conditions although with a 10% hypo solution the time of fixation is cut in half by brush treatment. The rate of agitation produced in the average processing machine corresponds approximately to that produced by hand agitation.

V. The Efficiency of Acid Hardening Baths

The practical efficiency of a fixing bath is governed by the following factors:

1. The absolute times of fixation when the bath is fresh and when exhausted. In practice with motion picture negative emulsions a fixing bath is considered exhausted when the time required to clear the film is excessive, the limit being usually from 10 to 15 minutes; that is, it is considered better economy to prepare a fresh bath than to waste time waiting longer than 20 to 30 minutes for the film to fix, although at this point the bath is not actually exhausted because an emulsion could be satisfactorily fixed by prolonged treatment. (In practice the rule "time of fixing = twice the time to clear" is usually observed.)

2. The quantity of emulsion fixed during the active life of the bath. The active capacity may be defined as the quantity of film fixed up to the point when the time required to clear the emulsion is greater than a definite limit. This varies according to the particular emulsion to be fixed, the active capacity being much less in the case of slow fixing emulsions than in the case of rapid fixing emulsions which are usually more fine grained.

3. The staining limit of the bath, that is, the quantity of emulsion fixed before the bath stains the film with average manipulation. Staining in a fixing bath may be a result of (a) insufficient fixation or (b) lack of agitation especially in the presence of free developer. If the film is insufficiently fixed any residual silver thiosulfate ultimately decomposes producing a brown stain. Also, if the bath becomes alkaline because of developer carried into it by films, the free developer reduces the silver thiosulfate in the film to finely divided metallic silver *in situ* causing dichroic fog.[2]

4. The cost of the fixing bath. Although with negative motion picture film a 40% solution of hypo gives the most rapid fixation as compared with a 30% solution for positive motion picture film, the question arises as to whether the extra cost of the more concentrated solution is justifiable by the slightly shorter time of fixation. For average use, a 25% solution of hypo is satisfactory for fixing both positive and negative motion picture film though if time is the most valuable consideration a 40% solution for negative film is desirable.

VI. The Hardening Action of Fixing Baths

Potassium and chromium alum are the most desirable hardening agents for use in an acid fixing bath but the present discussion will be confined exclusively to the hardening properties of fixing baths compounded with potassium alum.

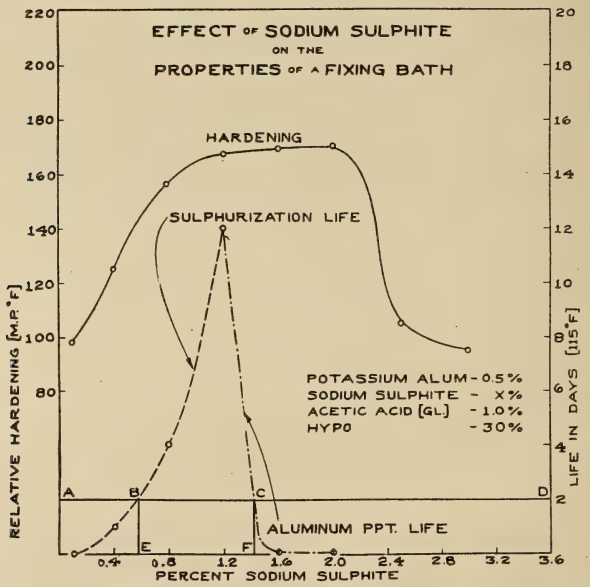

FIGURE 3. Effect of the addition of sodium sulfite to a fixing bath on (a) the hardening properties, (b) the sulfurization life, and (c) the aluminium precipitation life.

At the outset, it was considered that a fixing bath formula might be compounded by merely determining (a) the quantity of alum necessary to produce satisfactory hardening (b), the quantity of acid necessary to prevent the precipitation of aluminium sulfite on the addition of a given quantity of developer to the alum solution,

and (c), the quantity of sulfite which it was necessary to add to this mixture to prevent the precipitation of sulfur from the hypo in the presence of the acid.

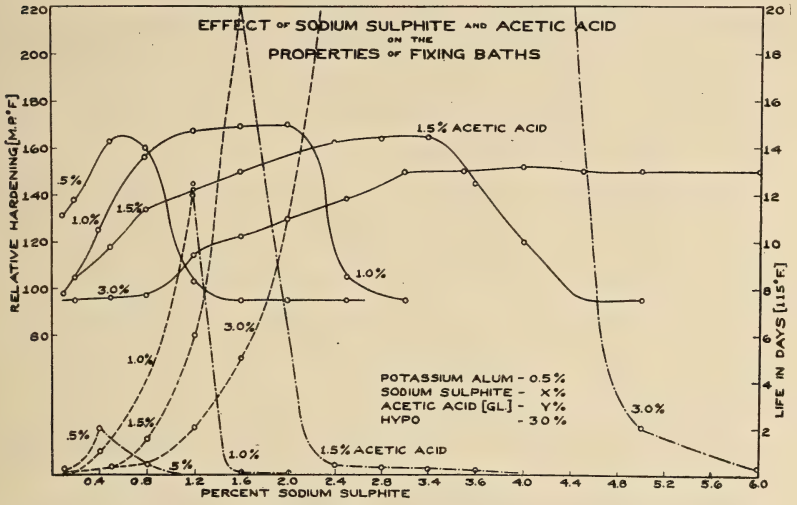

FIGURE 4. Effect of the addition of sodium sulfite and acetic acid on the properties of a fixing bath containing 0.5% potassium alum.

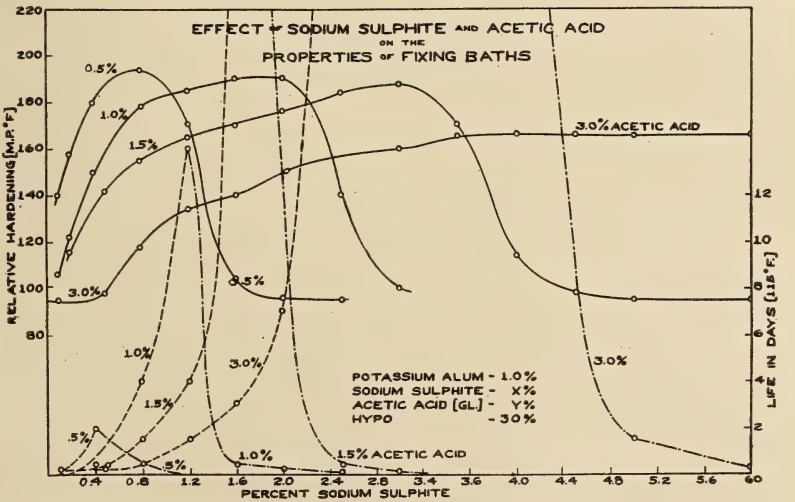

FIGURE 5. Effect of the addition of sodium sulfite and acetic acid on the properties of a fixing bath containing 1.0% potassium alum.

Preliminary experiments indicated, however, that the hardening produced by a fixing bath was not merely a function of the alum or acid content but was determined by the relation between the concentration of acid, sulfite, and alum and was independent of the quantity of hypo. Therefore, in order to determine the correct proportion of the various constituents to produce an acid hardening fixing bath having any desired properties, it was necessary to study the effect of each constituent in the presence of varying proportions of the other two constituents.

In Fig. 3, the full line represents the progress of hardening on the addition of sodium sulfite to a bath containing 0.5% alum, 1.0% acetic acid, and 30% hypo. The "dash" line represents the tendency of such a bath to precipitate sulfur with various concentrations of sulfite while the "dash and dot" line indicates the tendency of the bath to precipitate aluminium sulfite with increasing additions of sulfite. The last two curves are plotted in terms of days of storage at 115° F. indicated on the right side of the chart.

Figs. 4 and 5 represent a multiple set of curves corresponding to those shown in Fig. 3 for fixing baths containing 0.5% and 1.0% of potassium alum, varying concentrations of acetic acid (0.5 to 3.0%), and increasing concentrations of sulfite.

1. Factors Influencing the Hardening Properties of Potassium Alum Fixing Baths. From a study of Figs. 3, 4, and 5, it is seen that (1) the hardening produced is a function of the relative proportion of the acetic acid, sodium sulfite, and potassium alum; (2) for given quantities of sulfite and alum the hardening decreases as the concentration of acid increases; (3) for given quantities of acid and alum the hardening increases to a maximum with increasing concentration of sulfite after which the hardening decreases, that is, there is a critical quantity of sulfite for each concentration of acid which gives maximum hardening; (4) the maximum hardening produced in any case increases when the concentration of alum is increased; (5) in any particular case, the maximum hardening obtainable with a given concentration of alum decreases as the concentration of acid increases. The decrease is not appreciable with acid concentrations below 2.0% but it is more marked as the acid concentration is increased above this quantity.

The effect of temperature on the hardening produced by a fixing bath is shown in Fig. 6 which indicates that the hardening increases by the following table.

slightly as the temperature of the fixing bath increases. The time of fixation also affects the hardening produced as indicated by Fig.

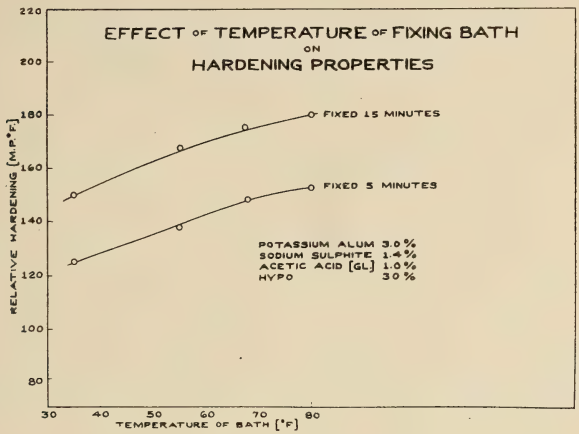

FIGURE 6. Effect of temperature of a fixing bath on its hardening properties.

7. The age of a potassium alum-acetic acid fixing bath previous to use, has little or no effect on the hardening properties as is likewise

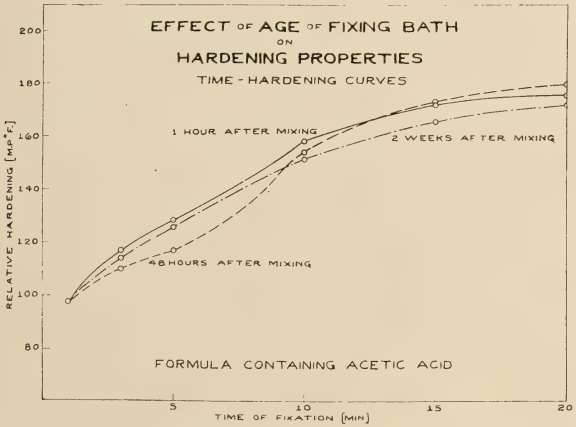

FIGURE 7. Effect of age of fixing bath on its hardening properties

shown by Fig. 7. The quantity of alkali in the film when placed in the fixing bath also affects the hardening produced as indicated.

TABLE II

Effect of Time of Rinse Between Development and Fixation on Hardening Properties of a Fixing Bath

Time of Rinse	*Relative Hardening (M.P.°F.)*
0.0 min.	170°F.
0.5 min.	185°F.
1.0 min.	186°F.
2.0 min.	188°F.
5.0 min.	190°F.

2. Factors Influencing the Sulfurization Life. From the curves shown in Figs. 3, 4, and 5, it is seen that (a) for equal concentrations of alum and acid, the sulfurization life increases rapidly as the quantity of sulfite increases, the sulfurization life apparently increasing logarithmically with the concentration of sulfite; (b) for equal concentrations of alum and sulfite, the sulfurization life decreases as the concentration of acid is increased; (c) for equal concentrations of acid and sulfite the sulfurization life decreases only slightly with increasing concentration of alum.

3. Factors Affecting the Developer Capacity. In order to determine the developer capacity (the quantity of developer which can be added to the fixing bath before precipitation of aluminium sulfite occurs) for all of the formulas represented by the various points in the curves shown in Figs. 3, 4, and 5, it would have been necessary to prepare a large quantity of these formulas and determine the quantity of developer necessary to precipitate aluminium sulfite in each case. In was considered desirable, therefore, to find a method whereby the curves already obtained could be interpreted in terms of "developer capacity." Curves 3, 4, and 5 show that with an increasing quantity of sulfite there is a tendency to precipitate aluminium sulfite, while with an insufficient quantity of sulfite, sulfur tends to precipitate. It is between these two limits that a suitable stable fixing bath exists; in other words, there is a definite quantity of sulfite which may be added to any given formula which is satisfactory with regard to sulfurization life before the precipitation of aluminium sulfite occurs. It was thought that it might be possible to find a definite relation between this quantity of sulfite and the quantity of developer which would cause similar precipitation. Experiments were therefore made to determine this relation by comparing the quantity of developer in one case, and the quantity

of sulfite in the other case necessary to precipitate aluminium sulfite in the case of typical formulas. The formulas tested were so chosen that the sulfurization life was equal in all cases. The following table gives the results of these experiments.

TABLE III

The Relative Effect of Developer (MQ_{25}) and Sodium Sulfite on the Precipitation of Aluminium Sulfite in a Fixing Bath

	% Sod. Sulfite to Cause Precip.		*% MQ_{25} to Cause Precip.*		*Ratio MQ_{25} Sod. Sulfite*		*Composition of Bath*			
	70°F.	*115°F.*	*70°F.*	*115°F.*	*70°F.*	*115°F.*	*% Potassium Alum*	*% Sodium Sulfite*	*% Acetic Acid*	*% Hypo*
1.	4.6	1.0	30	7	6.5	7.0	1.5	1.2	1.5	30
2.	5.5	2.6	36	20	6.6	7.7	1.5	3.0	1.6	30
3.	2.4	1.4	15	8	6.3	5.7	1.0	1.0	1.5	30
4.	5.5	5.1	40	34	8.0	6.7	0.5	1.5	3.0	30
5.	1.7	3.8	14	22	8.2	5.8	3.0	2.6	3.0	30
				Average	7.1	6.6				

These results show that although the relation is not constant the results are sufficiently uniform to permit their use in determining the relative developer capacity from the curves in Figs. 4 and 5. It is considered that the ratio of approximately 1:6 is permissible; that is, for 1.0% sodium sulfite which may be added to a given formula before precipitation of aluminium sulfite occurs 6.0% of MQ_{25} developer may be added before a similar precipitate will be formed. In applying these results to developers other than MQ_{25} it is necessary to know the alkali and sulfite content of the developer in relation to that of the MQ_{25} developer.

From the curves (Figs. 4 and 5) it is seen that (a) for equal concentrations of alum and acid the developer capacity decreases with an increased quantity of sulfite; (b) for equal quantities of sulfite and alum the developer capacity increases as the concentration of acetic acid increases; (c) for equal quantities of sulfite and acid the developer capacity is only slightly affected by an increased concentration of alum.

4. The Application of Hardening Curves to the Preparation of Fixing Baths Having Required Properties. From the curves (Figs. 3, 4, and 5) it is possible to compound a fixing bath having any given properties. The following three factors must be known before a suitable fixing bath may be compounded: (a) the hardening desired; (b) the developer capacity, and (c) the sulfurization life. With this information available, the series of curves (Figs. 3, 4, and 5) which gives the maximum hardening desired is selected and from these curves the necessary quantity of alum is determined. Then, by drawing a line parallel with the sodium sulfite axis at a distance from it representing the desired sulfurization life as indicated on the axis "life in days," and determining the limits of the sulfite content between the sulfurization and aluminium precipitation curves, the quantity of acid necessary is indicated by the curves whose sulfite limits correspond to one-sixth of the developer life desired. Then, by projecting the point of intersection of this parallel line and the sulfurization life curve to the sodium sulfite axis, the quantity of sulfite sufficient to give the necessary sulfurization life is indicated. This gives the complete hardening formula which may be added to a quantity of hypo as determined by the amount of film to be fixed and the rate of fixation desired.

5. Example of Use of Curves in Compounding a Fixing Bath Formula. If it is desired to compound a fixing bath having the following properties; relative hardening 160° F., sulfurization life 2 days (110° F.), developer capacity 6% MQ_{25}, proceed as follows:

It is seen from Fig. 3 that the maximum hardening produced by an 0.5% potassium alum solution with varying concentrations of sodium sulfite is approximately 160° F. Draw a line parallel with the sodium sulfite axis at a distance from it represented by two days on the sulfurization life curve at B and the aluminium precipitation curve at C. Project the points B and C to the sodium sulfite axis to the points E and F, respectively. The difference in the sodium sulfite concentration represented by these two points multiplied by 6 gives the relative developer capacity for the acidity (1.0%) which is represented by these curves; that is, 1.5% — 0.6% = 0.9%; 0.9% x 6 = 5.4% equivalent developer capacity. The quantity of sulfite represented by point E (0.6%) is the quantity necessary to give the desired (2 days) sulfurization life. This information gives the proportion of the various ingredients (0.5% potassium alum, 0.6%

sodium sulfite, 1.0% acetic acid) required to produce a fixing bath having the above desired properties. This hardener may then be added to a given hypo solution and the fixing bath is then complete.

Fig. 3 was used for the above example merely for the purpose of simplicity. In order to compound fixing baths having properties other than the above it is necessary to refer to Figs. 4 and 5 or additional sets of curves for other concentrations of alum.

In choosing the alum concentration, the minimum quantity which will give the necessary hardening is desirable. The quantity of sulfite to insure the necessary sulfurization life (X days at 115° F.) is then determined as indicated above. The quantity of acid is decided upon by finding the set of curves (aluminium precipitation life and sulfurization life) such that the space between them at a distance of two days* from the sulfite axis corresponds to one-sixth of the developer capacity. The acid concentration represented by this chosen set of curves gives the acid concentration to use in the formula. With this fixing bath it is therefore possible to add a quantity of sulfite X (as represented by a developer life of 6X) in addition to that already present in the formula before a precipitate of aluminium sulfite is formed.

The formula given above represents a suitable stable acid hardening fixing bath which might be used in cases where only a relatively small quantity of developer is carried into the fixing bath. Fig. 8 shows the effect of the addition of developer on the hardening properties of this formula. It is seen that the hardening at first is not as high as desired, but with the addition of a small quantity of developer the hardening increases to the desired limits, and with the addition of further developer (about 5% MQ_{25}) the hardening falls off and the bath is rendered useless by the formation of a precipitate.

6. The Effect of Excessive Hardening. Excessive hardening is apt to render the gelatin opalescent especially if the temperature of the fixing bath is slightly above normal. The opalescence is usually removed during subsequent washing and drying and is ordinarily unobjectionable. If, however, the opalescence persists after wash-

* If the bath does not precipitate a sludge of aluminium sulfite in 2 days at 115°F., it will not sludge at room temperature within a period of one to two weeks and is therefore satisfactory.

ing, it may be removed by bathing the film in a dilute (1.0%) solution of sodium carbonate. This must be done at a relatively low temperature (not above 65° F.) because the carbonate solution destroys the hardening, permitting the gelatin to soften and swell which may be followed by subsequent reticulation at higher temperatures.

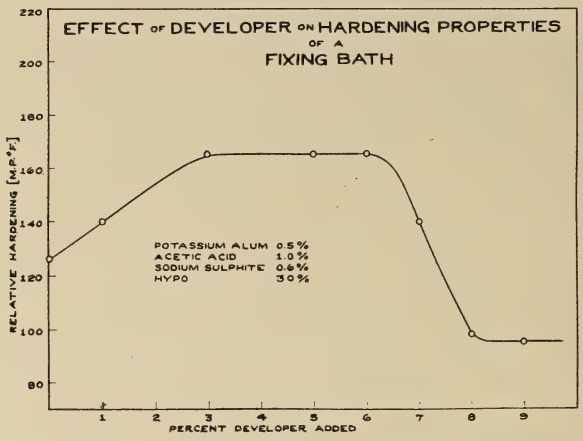

FIGURE 8. Effect of the addition of developer on the hardening properties of a fixing bath.

It has also been considered that excessive hardening of the gelatin film increases the brittleness of motion picture positive film thus shortening its projection life. In order to check this, samples of positive and negative motion picture film were treated with an acid alum fixing bath so as to give melting points of 125° F. and 180° F. respectively. These films were stored for six months at 115° F. and at a relative humidity of 80%, and then stored for one year at 70° F. and 60% relative humidity. The films were tested for brittleness and the tendency of the emulsion to strip from the base at intervals during the keeping tests, and in no case was there any tendency of the emulsion to strip, while the films at no time were unduly brittle.

It is therefore considered that provided motion picture film is properly processed and thoroughly washed and stored under suitable conditions of temperature and humidity, moderate hardening with potassium alum does not materially impair the keeping properties of gelatin films.

VII. Factors Governing the Tendency of a Fixing Bath to Produce Blisters

A large quantity of acid is desirable in a fixing bath because it permits the addition of a large quantity of developer before a sludge of aluminium sulfite commences to form. An excess of acid, however, may cause sulfurization which in turn can be retarded by the addition of sulfite or a buffer salt such as sodium acetate[15] but the sulfite in turn lowers the developer capacity whereas the acid was added to raise this capacity in the first place. The quantity of acid which can be added is likewise limited by the tendency of the bath to produce blisters on the films treated. The formation of blisters is largely due to the liberation of carbon dioxide or possibly sulfur dioxide formed by the action of the acid on the carbonate or sulfite in the developer retained by the film. The gases emitted in this manner form little gas bells in the gelatin which break when the pressure becomes sufficiently great producing a crater-like appearance in the gelatin.

It was found that the tendency of a fixing bath to produce blisters is governed by the following factors:

1. The quantity of sulfite and carbonate contained in the film when immersed in the fixing bath, which in turn depends upon the sulfite and carbonate content of the developer, and the extent of the rinse, if any, between developing and fixing.

2. The rate of agitation of the film when first immersed in the fixing bath. Agitation removes the excess developer from the surface of the film and hastens its diffusion out of the gelatin, thus rapidly lowering the content of alkali. Agitation of the films several seconds after immersing in the fixing bath is one of the most effective means of preventing blisters.

3. The nature and thickness of the gelatin film. Films having a thick coating of gelatin under given conditions blister much more readily than thinly coated films.

4. The duration of the rinse or wash as commonly used between developing and fixing. The longer and more complete the wash with respect to the removal of the developer, the less is the tendency of the fixing bath to blister, because the substances which cause blistering have either been removed completely or their con-

centration so reduced that few or no gas bubbles are formed when immersed in the fixing bath.

5. The degree of swelling of the gelatin when first placed in the fixing bath which, in turn, depends upon the nature of the gelatin and temperature and composition of the developer, and the time of development.[16]

6. The acidity of the fixing bath. It was at first thought that the active acidity as represented by the hydrogen ion concentration measurements might be a measure of the tendency of a fixing bath to blister. The hydrogen ion concentration was determined for fixing baths containing widely varying quantities of sodium sulfite, acetic acid, and potassium alum, but in all cases the pH values were approximately constant varying only from 4.5 to 4.7 although the tendency of the baths to produce blisters varied considerably. It is apparently not possible to correlate the hydrogen ion concentration figures with the propensity of a given bath to blister because a stable bath is sufficiently buffered to maintain a constant hydrgen ion concentration regardless of the concentration of acid used.

It was observed that the tendency of a bath to cause blisters increased as the total acidity was raised above the value at which blisters were found under average practical working conditions. The total acidity was determined by the quantity of a known alkali required to neutralize a given quantity of the fixing bath. Since the developer (MQ_{25}) represents a known alkali and since it was used in all other cases in the testing of the properties of a fixing bath, it was also used to determine the total acidity of a fixing bath. The results are expressed in terms "the number of c.c. of MQ_{25} developer required to neutralize 100 c.c. of fixing bath using phenolphthalein as indicator." It was considered that for practical purposes when a normal rinse is employed between developing and fixing and when the temperature does not exceed 70° F. to 75° F. the acidity of a fixing bath should not be greater than 150 c.c. For temperatures above 75° F. to 85° F. an acidity of 30 c.c. to 50 c.c. only is permissible.

VIII. The Revival of the Hardening Properties of Fixing Baths

Even the most suitable acid hardening fixing bath compounded according to previous discussion is rendered unsatisfactory for fur-

ther use by the addition of developer long before the hypo is exhausted; that is, the various properties of the bath are so impaired that the fixing bath is rendered useless for further fixation because of (1) a decrease in the hardening properties; (2) the formation of a precipitate of aluminium sulfite; or (3) a sufficient decrease in acidity to permit discoloration of the bath, while the fixing power of the hypo still remains adequate for further use. It might be argued that the concentration of the hypo would be so cut down that the hypo and hardener would be exhausted at the same time, but to meet this condition the concentration of the hypo would need to be inefficiently low.

In order to determine the most suitable method of reviving the hardening properties it was necessary to determine first, the products formed during exhaustion and, secondly, the effect of these products on the properties of the fixing bath.

1. Products of Exhaustion and their Effect on the Hardening Properties of a Fixing Bath. During exhaustion of a fixing bath, the following products accumulate therein: developer and developer oxidation products, sodium silver thiosulfate, sodium bromide and sodium iodide, sodium acetate, sodium bisulfite, sodium sulfate, basic aluminium sulfites, and occasionally, free sulfur.

The sodium acetate and sodium bisulfite are a result of interaction between the acetic acid and the sulfite and carbonate carried in by the developer while some of the sodium bisulfite is converted to sodium sulfate by aërial oxidation. The sodium bromide and iodide are products of reaction from the fixation of bromo-iodide emulsions.

The addition of sodium acetate and sodium bisulfite to a fresh bath tends to increase the hardening produced and the sulfurization life of the path. Sodium acetate does not affect the tendency of the path to precipitate aluminium sulfite, while sodium bisulfite only slightly increases this tendency. Neutralization of the sodium carbonate by the acetic acid reduces the acidity of the bath and by reference to the curves in Figs. 3, 4, and 5, it is seen that as the acidity is decreased the hardening increases up to the point at which aluminium sulfite precipitates.

It was also considered possible that the exhaustion of the bath by a given number of films might be accompanied by the absorption or removal of a given quantity of alum by virtue of the harden-

ing imparted to the film, but this was shown to be negligible for all practical limits of exhaustion; that is, the quantity of alum removed by a given quantity of film was not sufficient to affect the hardening properties of the bath. This was determined by quantitative estimation of the alum content of a bath before and after exhaustion.

The other products of exhaustion: namely, silver mono- and disodium thiosulfate, developer oxidation products, and sodium and potassium bromide were found to have little or no effect on the hardening properties.

It is therefore apparent that the cause for the decrease in hardening and general usefulness of a hardening fixing bath when exhausted to the point at which aluminium sulfite precipitates is the unbalanced condition brought about by the neutralization of the excess acid by the carbonate of the developer carried into the fixing bath, and also by the added effect of the increased quantity of sulfite present. For all practical purposes, therefore, it would appear that the revival of a fixing bath should be accomplished by the addition of a given quantity of acid at certain intervals.

2. When Should a Fixing Bath be Revived? The frequency of revival or the stage of exhaustion at which the revival should take place depends upon the following factors:

(a) The original acidity of the bath, and

(b) The degree of uniformity of hardening required.

(a) As stated previously a large quantity of free acid in a fixing bath is desirable on the one hand because this increases the developer capacity; but it is also undesirable because the propensity of the bath to blister and precipitate sulfur is increased while the hardening properties of the bath are impaired. If maximum hardening and sulfurization life are required, a minimum quantity of acid should be used but this will necessitate very frequent revivals with acid. If revival is not possible or undesirable, then the largest quantity of acid which will give the desired hardening and sulfurization life should be used, though experiments have shown that the best formula which it is possible to compound is inefficient unless revived, because the bath will precipitate aluminium sulfite long before the fixing powers of the hypo are exhausted.

It was considered that it might be possible to employ a high original acidity by suitable buffering of the acidity as suggested by F. A. Elliott (U. S. Patent 1,411,687), but it has been shown by

practical experiments that, although certain buffer salts, such as sodium acetate, tend to maintain the hardening properties and sulfurization life, they do not materially decrease the propensity of the bath to blister and are therefore of correspondingly less practical value.

(b) From Fig. 8 it is seen that as a fixing bath becomes exhausted the hardening increases up to the point at which aluminium sulfite precipitates and then decreases so that the best point at which to revive with acid would be that just previous to the precipitation. It is dangerous, however, to approach the precipitation point too closely, because once the aluminium sulfite has precipitated, a relatively large quantity of acid must be added to bring it back into solution, the balance of the bath is destroyed, and it is liable to cause blisters. If the quantity of acid permissible for satisfactory hardening is added the precipitate disappears very slowly and it is necessary to revive at such a time when it is possible to allow the bath to stand for a day or two in order to dissolve the precipitate completely.

The effect of reviving a bath with varying quantities of acid at different stages before the aluminium sulfite precipitation point is shown in Figs. 9 and 10. These curves were obtained from results of tests made under practical working conditions in a motion picture finishing plant and are considered to represent average working conditions. The properties of the baths were tested only before and after revival, and therefore straight lines were drawn between the points representing the properties of the bath at the time of the tests.

The acidity, hardening, sulfurization life, and developer capaciey curves have all been assembled in one figure and the respective data are given for each stage of exhaustion determined by a definite number of feet of motion picture film fixed in the bath.

Test A (Fig. 9) represents the properties of a bath revived with too much acid at too infrequent intervals, while test B (Fig. 10) represents a more satisfactory method of revival where a smaller quantity of acid was added at more frequent intervals. The results indicate that there is a greater variation in the properties of the bath in test A than in the case of test B. In both cases the acidity was maintained within satisfactory limits while the relative hardening varied from 90° to 160° (M.P. °F.) in test A and from 120° to 155° (M.P. °F.) in test B. The sulfurization life varied in test

A from one-half day to six days, and in test B from one day to six days. It is considered that a fixing bath which precipitates sulfur in one-half day at 115°F. should not be stored for too long a period at room temperature before use because the propensity

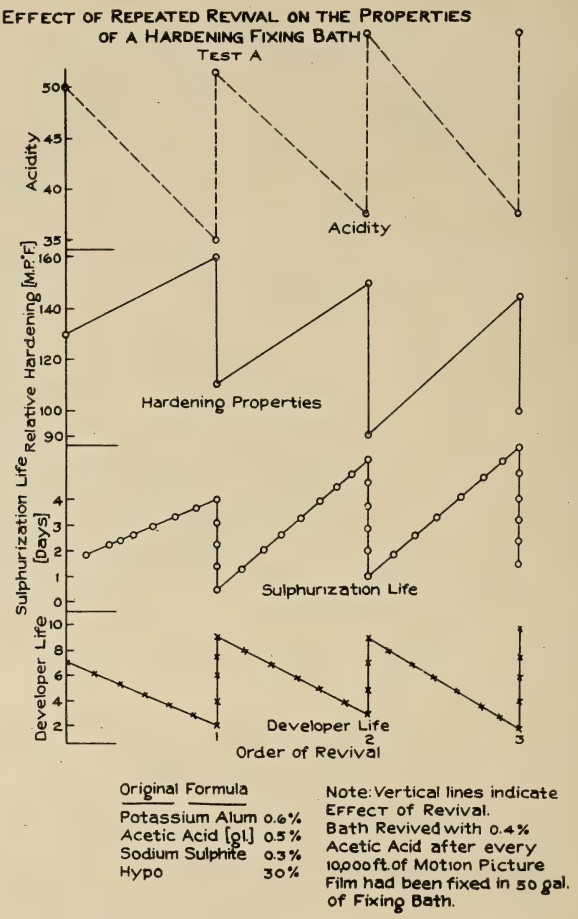
EFFECT OF REPEATED REVIVAL ON THE PROPERTIES OF A HARDENING FIXING BATH
TEST A
Acidity
Acidity
Relative Hardening [M.P.F.]
Hardening Properties
Sulphurization Life [Days]
Sulphurization Life
Developer Life
Developer Life
Order of Revival
Original Formula
Potassium Alum 0.6%
Acetic Acid [gl.] 0.5%
Sodium Sulphite 0.3%
Hypo 30%
Note: Vertical lines indicate Effect of Revival. Bath Revived with 0.4% Acetic Acid after every 10,000 ft. of Motion Picture Film had been fixed in 50 gal. of Fixing Bath.

FIGURE 9. Effect of repeated revival with acid on the properties of a hardening fixing bath.

to precipitate sulfur is too great. The developer capacity varied from 2% to 10% MQ_{25} for test A and from 4% to 10% MQ_{25} in test B. It is considered that a bath which requires only 2% MQ_{25} to precipitate aluminium sulfite at normal temperature is too near

the point of precipitation to be satisfactory for further use because of the propensity to precipitate a scum on the surface of the film. If the fixing bath had not been revived a precipitate of aluminium sulfite would normally have occurred after about 17,500 feet of

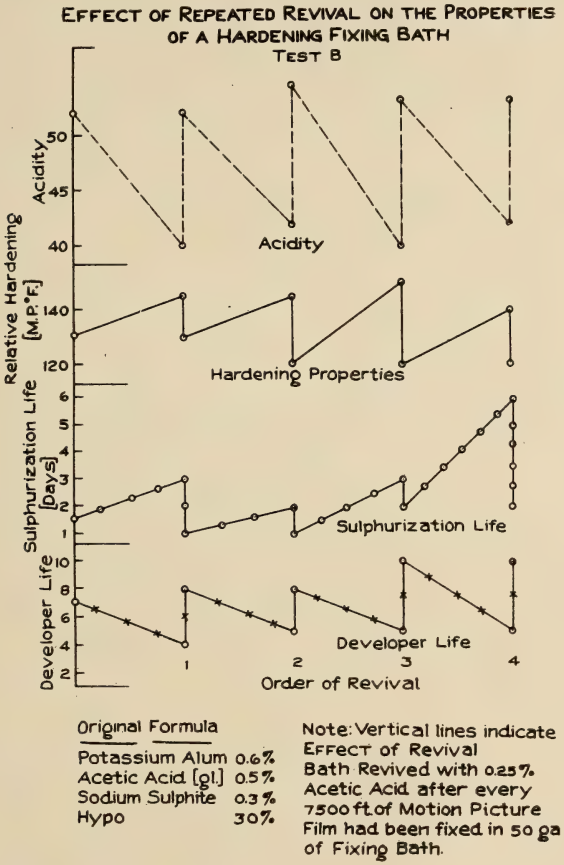

FIGURE 10. Effect of revival with acid at more frequent intervals than in the case of Figure 9.

film had been fixed per 50 gallons. By reviving as above the life was prolonged to 30,000 feet.

It is also apparent that the properties of the fixing bath remain more nearly uniform with frequent revivals using smaller quantities of acid. If the bath had been revived at sufficiently frequent intervals the various curves would tend to approximate

a straight line from the fresh to the exhausted bath. However, it was concluded that revival with acid in the proportion of 1 pint (500 c.c.) per 120 gallons of bath after processing 7,500 feet of film was sufficient to prevent the bath from becoming impaired with regard to the propensity of the bath to precipitate aluminium sulfite and that the acid necessary to restore the properties of the bath and maintain satisfactory developer life until the next revival was not sufficient to impair the hardening properties and sulfurization life of the bath. It was also concluded that practical procedure in a motion picture laboratory would not warrant more frequent revival because of the time and delay accompanying such procedures.

3. Methods of Determining the Revival Point. (a) As outlined above, the revival point or stage of exhaustion at which the bath should be revived is largely arbitrary, depending upon the degree of uniformity of hardening desired; that is, for more uniform hardening the bath should be revived at frequent intervals although in practice it is usually satisfactory if revival takes place just previous to the point at which aluminium sulfite is precipitated.

At the outset it was thought that it might be possible to add to the bath an acid indicator which would change color just previous to the point at which precipitation of aluminium sulfite occurs, although the color of the indicator either in the fresh or exhausted bath would have to be complementary to the safelights used in order to permit of detection of the color change in the darkroom. No perfectly satisfactory indicators for the purpose are at present known.

(b). It is possible to determine the quantity of sodium sulfite and sodium carbonate added to the fixing bath during the process of fixation by titrating the fixing bath with a known alkali using suitable indicators. From this information the quantity of acid necessary to bring the bath back to its initial stable condition can be calculated. However, in order to determine this it would not only be necessary to consult the curves for the compounding of a fixing bath, but it would also be necessary to determine the effect of the exhaustion products from the other curves indicated above. This would complicate the procedure to such an extent that it would not be applicable to average darkroom procedures.

(c). Since none of the above methods is readily adaptable for darkroom use the only alternative was to determine the period of revival by means of a quantity factor. Every darkroom worker

knows, or should know, roughly the footage of film treated which has carried over a definite volume of developer to the fixing bath, assuming a constant period of drainage or rinsing between developing and fixing. Usually only one developer is used in connection with any fixing bath, but in case different developers are used, containing varying quantities of alkali, a slight correction factor should be used. The quantity of film fixed is, therefore, a measure of the quantity of developer added to the fixing bath, and therefore of the degree of exhaustion.

The point at which the revival should be made should be selected as outlined above. On an average it is advisable to revive at the half-way stage towards the sludging point. By experience the quantity of film necessary to cause a precipitate of aluminium sulfite is known and the bath should be revived when half this quantity has been treated. Thus, in the case of motion picture film if it requires 15,000 feet of film under given conditions to cause a precipitate with, say, 50 gallons of fixing bath, revival should take place after treating 7,500 feet of film.

4. The Quantity of Acid to be Added at Each Revival. As seen from Figs. 3, 4, and 5, it is necessary to increase the concentration of the acid as the concentration of the sulfite is increased in order to render the bath stable with regard to the precipitation of aluminium sulfite and for this reason it is apparent that the total acidity of a revived bath should be slightly higher than the acidity of the fresh bath in the first place. This increase in acidity cannot be definitely determined, but depends upon the procedure as followed by the individual worker, because various procedures permit the carrying over of varying quantities of developer into the fixing bath, depending upon the concentration of the developer and the period of rinse between development and fixation.

IX. Summary

1. A criterion for the comparison of various fixing baths has been developed and includes a consideration of (a) the time of fixation; (b) the degree of hardening produced; (c) the sulfurization life; (d) the developer capacity or the quantity of developer which can be added before a precipitate of aluminium sulfite is produced; (e) the propensity to blister; and (f) cost.

2. A series of arbitrary tests has been devised whereby it is possible to determine the merits of any particular fixing bath with relation to the criterion as outlined above.

3. For fixing Eastman negative motion picture film a 40% solution of hypo is most efficient and for Eastman positive motion picture film a 25% solution gives maximum efficiency. When a bath is used for both negative and positive film, a concentration of 30% is satisfactory.

4. The hardening produced by potassium alum solutions of various concentrations is affected by the addition of acetic acid and sodium sulfite. For a given quantity of alum and acid the hardening increases to a maximum on the addition of sodium sulfite, then diminishes and finally a precipitate of aluminium sulfite is formed. With fixed concentrations of alum and sodium sulfite the hardening decreases as the acid concentration is increased.

From a series of curves showing the effect of variation in the proportions of alum, sulfite, and acid on the sulfurization and hardening life and the tendency of the bath to precipitate aluminium sulfite, it is possible to compound fixing baths having any desired properties.

5. Sodium sulfite may be replaced by sodium acetate in a fixing bath but sodium acetate is only one-fifth as efficient as sodium sulfite as a sulfurization inhibitor.

6. In certain cases, the acidity of a potassium alum fixing bath cannot be sufficient to keep the bath clear during the addition of a large quantity of developer because the acidity is limited by the propensity of the bath to blister and sulfurize. Under certain conditions where the efficiency of the fixing bath is determined by the quantity of developer which may be added before aluminium sulfite is precipitated, it has been shown that the addition of acid at frequent intervals during exhaustion of the bath is a material advantage.

X. Practical Recommendations

In motion picture work the nature of the most satisfactory fixing bath to be used depends on the particular photographic procedure adopted. For instance, if an acid stop bath is used after developing, high acidity of the fixing bath is not necessary, while

if both rapid fixation and excessive hardening are desired the fixing bath must harden more rapidly than if a longer time of fixation were permissible.

It is not absolutely necessary to harden the gelatin coating of motion picture film, but a hardened negative film has a less propensity to become finger marked during handling, while with positive film hardening during fixation is desirable because (a) this permits more rapid drying of the film; (b) if the film is developed by the rack system, the hardened gelatin coating is less liable to be abraded when wiping the film during transference to the drying reel;[4] and (c) if the film is relatively moist during projection, there is less tendency for the film, if hardened, to stick in the projector gate.

Non-hardening Fixing Baths

If the temperature of the various developing solutions can be maintained at a temperature not higher than 65°F. and if ample drying time is allowed so that relatively cool drying air can be used, the following non-hardening fixing bath is satisfactory:

	Metric	*Avoirdupois*
Hypo	240 grams	100 lbs.
Sodium sulfite (desiccated)	10 grams	4 lbs.
Sodium bisulfite	25 grams	10 lbs
Water to make	1 liter	50 gallons

The bisulfite serves to keep the bath acid and prevents stains while the sulfite prevents precipitation of sulfur if the bath is stored previous to use at too high a temperature. The bath should be maintained acid by reviving with a 25% solution of sodium bisulfite at intervals or in the case of machine processing, by allowing this reviving solution to flow into the tank continuously during use.

An alternative method of revival consists in passing sulfur dioxide gas into the bath. Although this method is efficient in practice, there is danger of accidental escape of the suffocating gas into the atmosphere of the laboratory.

Acid Hardening Fixing Baths

In most cases it is desirable to harden motion picture film to a moderate degree during processing and a satisfactory acid hardening fixing bath for both negative and positive motion picture film should possess the following properties:

(a) The melting point of the fixed-out film should range from 120° to 160° F.

(b) If the sulfurization life of the bath is one and one-half days at 115° F. the bath will keep satisfactorily for about three weeks at 70° F. which is ample for most purposes.

(c) The developer capacity should be such that at least 3% of MQ_{25} developer can be added before a precipitate of aluminium sulfite is formed. This capacity is considered adequate especially if the bath is revived at intervals with acid.

On reference to Fig. 4 it is seen that the following formula possesses the above properties and in practice this formula has been found to be entirely satisfactory.

Fixing Bath (Formula F-2)

	Metric	*Avoirdupois*
Hypo	240 grams*	100 lbs.
Water to make	1 liter	50 gallons

Add to 50 c.c. per liter or 2½ gallons per 50 gallons of the following Stock Hardener:

* The concentration of hypo to be used may be varied to satisfy individual requirements.

Stock Hardening Solution (Formula F-2a)

	Metric	*Avoirdupois*
Sodium sulfite (desiccated)	60 grams	25 lbs.
Acetic acid (glacial)**	100 c.c.	5 gallons
Powdered potassium alum	120 grams	50 lbs.
Water to make	1 liter	50 gallons

** Use 3½ times the quantity if 28% acetic acid is used.

The hardening solution should be prepared separately and added to the cooled hypo solution as required. To prepare the hardener, dissolve the sulfite and alum separately, add the acid to the sulfite solution, and then add the alum solution, adding water to make the required volume. Do not add the sulfite to the alum solution before adding the acid or a precipitate will form.[17]

When the hardener is stored a white incrustation of basic aluminium acetate tends to precipitate out on the walls of the container but this does not impair the hardening properties of the solution. During storage in an open crock it is important to use a floating cover consisting of a sheet of No. 1 Kodaloid in order to prevent loss of sulfur dioxide and oxidation of the sulfite by the

air, otherwise in the absence of the necessary sulfite the hardener will cause the bath to sulfurize.

1. Temperature of the Fixing Bath. Under normal conditions the bath should be maintained at a temperature between 65° to 70° F. for most efficient fixation. If the temperature is higher than this, the gelatin is liable to soften before the hardening materials have been able to harden the gelatin sufficiently to withstand a higher temperature while if the bath is below 65° F., the rate of fixation is impaired and maximum efficiency is not obtained.

2. Time of Fixation. The times required to clear the emulsion of positive and negative motion picture film at 65° F. with and without agitation[4] during the active life of the bath (rack and tank method) are shown in Table IV. The bath was revived with acid at intervals but, of course, was continuously diluted by the water carried over by the racks from the rinse bath.

The time of fixation with agitation may be taken as a rough measure of the times for fixing with machine development. Recent experiments have shown that the emulsion is fixed out when all signs of opalescence of the film have disappeared so that for all practical purposes the film is fixed as soon as it clears. However, with most hardening fixing baths a slight opalescence of the gelatin persists even after thorough fixation and washing but invariably disappears on drying. It is good practice, therefore, to fix the film for at least twice the time required to clear the emulsion appreciably.

3. The Degree of Hardening Produced. The melting point of positive motion picture film ranges from 120° F. to 160° F. throughout the active life of the bath when revived at intervals with acid as shown in Table IV. After each revival with acid, the degree of hardening rises from 20 to 30 degrees and gradually drops again as the bath is used and more developer is carried into the bath by the film. In this case, the bath was on the verge of sludging at the revival point so that the hardening increased on the addition of acid. In the case of the curves shown in Figs. 9 and 10 the hardening decreased on revival with acid because the bath was much more remote from the sludging point at each revival. The hardening curve for a fixing bath used in conjunction with the Eastman borax developer[18] (which contains a high concentration of sulfite) is somewhat different. Since the addition of an excess of sulfite to a fixing bath lowers the degree of hardening (Fig. 4) it is seen that if the

negative film is not rinsed in water and allowed to fix without agitation, this produces in effect, a fixing bath having a high concentration of sulfite in the gelatin layer whose hardening properties are at a minimum. It is very important, therefore, in the case of film developed in the Eastman borax developer, to agitate thoroughly on first immersing in the fixing bath otherwise little or no hardening will be produced and reticulation is likely to occur in hot weather.

TABLE IV

Effect of Exhaustion and Revival with Acid on the Time of Fixation and Degree of Hardening

Film Fixed	*Time to Clear M.P. Neg. Film*		*Retic. Pt.* M.P. Neg. Film Fixed 15 Min.*		*Time to Clear M.P. Pos. Film*		*Melting Point M.P. Pos. Film Fixed 5 Min.*	
per gal.	*A*	*S*	*WR*	*AR*	*A*	*S*	*WR*	*AR*
0	3′ 50″	6′ 50″	118°F.		30 sec.	70 sec.	150°F.	
50	4′ 30″	7′ 50″	118°F.					
100	5′ 30″	8′ 30″	128°F.	128°F.	35 sec.	85 sec.	160°F.	
150	6′ 30″	9′ 45″	133°F.					
200	7′ 30″	11′ 30″	140°F.	140°F.	40 sec.	95 sec.	110°F.	160°F.
250	9′ 15″	13′ 30″	140°F.					
300	10′ 00″	16′ 15″			47 sec.	105 sec.	135°F.	168°F.
350								
400					60 sec.	125 sec.	142°F.	152°F.
450								
500					70 sec.	155 sec.	141°F.	156°F.
550								
600					95 sec.	200 sec.	128°F.	148°F.
650								
700					100 sec.	240 sec.	128°F.	135°F.

Key to abbreviations: A—Agitation; S—Stationary; WR—Without Revival; AR—After Revival.

* In the case of negative film the melting point is somewhat indefinite when determined in water and the temperature at which the gelatin "puckered" or reticulated is recorded.

With machine development the agitation is adequate. Hardening data for the above bath during use when fixing negative film developed in the Eastman borax developer with agitation are shown in Table IV.

4. Revival of the Bath with Acid. An alum hardening fixing bath is usually rendered useless as a result of the formation of a precipitate of aluminium sulfite long before the fixing properties of the hypo are exhausted. A fixing bath can, however, be revived suc-

cessfully at intervals by adding a definite quantity of acetic acid. It has been found best to add 500 c.c. or one pint of glacial acetic acid after every 7,500 feet of film (positive and negative) are processed in 120 gallons of the bath. If more acid than the quantity recommended is added, blisters and sulfurization are liable to occur.

These figures refer only to the above fixing bath (formula F-2) when using either developer formula D-16 or the Eastman borax formula D-76 and rinsing thoroughly in water after development. With developers containing more or less alkali or sulfite than these developers, the quantity of acid added should be adjusted accordingly.

If a footage record of the film processed is not kept, the acidity of the bath should be tested by titrating with alkali, using phenolphthalein as indicator. When the total acidity has dropped to two-thirds of the original acidity, enough acid should be added to restore the original acidity. The best way to revive a fixing bath would be to add acid gradually at a very slightly greater rate than that at which the acid is neutralized, it having been found that with use the acidity of the fixing bath should be increased slightly in order to maintain its hardening properties. However, the method of revival by adding acid after treating a definite number of feet of film has been found to work very satisfactorily in practice and is to be recommended.

If the bath has deposited a sludge of aluminium sulfite through neglect in reviving with acid, it is not advisable to try to dissolve this sludge by adding acid, although if the precipitate is freshly formed, it will usually dissolve after revival with acid on standing over night.

5. Revival of Fixing Baths by the Addition of Hypo. With use, the rate of fixation falls off as a result of (a) removal of active thiosulfate ions by virtue of the formation of complex silver thiosulfate ions, (b) dilution of the bath as a result of the addition of developer or rinse water and removal of thiosulfate by the films to the wash water, (c) accumulation of sodium iodide formed as a by-product in the conversion of the silver iodide in the emulsion to silver thiosulfate.

It is quite possible to revive the bath at intervals by the addition of a concentrated solution (60% to 70%) of hypo and still retain the hardening properties. The frequency of revival is deter-

mined by the limits of the permissible times of fixation, and the actual quantity of hypo to add can only be ascertained by trial. Under no circumstances should solid hypo be added to the bath because this may tend to cause sulfurization.

With such revival, the point at which the bath should be discarded is determined mainly by the propensity of the bath to stain the film.

6. When to Discard the Bath. In practice, a fixing bath is discarded for one or more of the following reasons: (a) the bath sulfurizes; (b) a sludge of aluminium sulfite forms in the bath; (c) the bath becomes dark in color, stains the film or froths excessively; and (d) the time of fixation is excessive.

(a) The sulfurization life of the bath F-2 with use is shown in Fig. 10. When freshly mixed, a deposit of sulfur will commence to form after storing for one and one-half days at 115° F. but with use the acid content decreases and more sulfite accumulates so that the sulfurization life rapidly increases to three days at the above temperature. On revival with acid, the sulfurization life drops again to one day so that when reviving with acid in warm weather when the temperature of the bath may be higher than normal, the acid should be added very slowly and the bath should be put to use within one or two days after revival. Once the bath has deposited sulfur, it is impossible to redissolve the precipitate and the bath should be thrown away.

(b) If the bath is not revived with acid, it will precipitate a sludge of aluminium sulfite after processing about two hundred feet of positive film per gallon although this precipitation point depends upon the alkali and sulfite content of the developer and the degree of rinsing between developing and fixing. If the bath is revived with acid at intervals as recommended, no sludging will occur.

(c) After the bath becomes alkaline the developer carried over by the film oxidizes and stains the bath, but if revived with acid at intervals, the bath does not stain up to the point when the time of fixation becomes excessive.

(d) The fixing bath is usually discarded at the point when the time of fixation (twice the clearing time) is excessive. The limiting time of fixation which can be tolerated depends upon circumstances, but average maximum fixing times (twice the time to clear) for negative and positive motion picture film are 20 and 6

minutes, respectively, when it is usually more economical to discard the bath.

In the case of the F-2 bath containing 25% of hypo and without agitation of the film, the clearing time exceeds 10 minutes after fixing 200 feet of negative motion picture film per gallon. With positive film the clearing time exceeds 3 minutes after fixing 600 feet of film per gallon. With a degree of agitation corresponding to that existing with machine development at a moderate speed, with negative film the time to clear exceeds 10 minutes after fixing 300 feet per gallon while with positive film the time to clear is less than 2 minutes after fixing 700 feet per gallon. If the bath is revived by the addition of hypo at intervals the above footage figures will be increased accordingly.

7. Importance of Rinse or Stop Bath. Rinsing in water previous to fixing prevents the carrying over of developer into the fixing bath and this retards the formation of a sludge of aluminium sulfite in the absence of revival with acid. An excess of developer also lowers the hardening properties and renders the bath alkaline and liable to stain. Rinsing, therefore, prolongs the life of the fixing bath and insures that its various properties remain more nearly uniform throughout its life.

In the case of some processing machines when the film would be otherwise exposed to the air for several seconds after leaving the developer tanks and before entering the fixing bath, it is desirable to arrest development by the use of an acid stop bath consisting of a 2.5% solution of sodium bisulfite or a 0.75% solution of acetic acid. For hot weather processing, a 2.0% solution of chrome alum is desirable.[19] Such stop baths must be kept acid at all times. Fixing baths to be used in conjunction with such acid stop baths should obviously contain a minimum of acid in the first place.

8. Use of Two Fixing Baths. The practice of using two fixing baths in succession is to be recommended. When the first bath is exhausted it is replaced by a comparatively fresh second bath which in turn is replaced by a new one. This scheme insures more rapid fixation than the use of only a single bath. For example, if the film just clears in X minutes in the first bath when practically exhausted and is allowed to remain for $\frac{X}{2}$ minutes in the second bath, it will be likely to be fixed more thoroughly than if it remained for 2X

minutes in the first bath. Also, if the hardening properties of the first bath are impaired because of exhaustion, adequate hardening is produced in the second fresh bath. However, any stains or dichroic fog produced in the first bath are not removed in the second so that it is important to maintain the first one acid and agitate the film sufficiently on first immersion.

Fixing Bath Troubles

A. Sludging of the Fixing Bath: A fixing bath may turn milky immediately on adding the hardener, or after being in use for some time. The milkiness may be of two kinds:

1. If the precipitation is pale yellow and settles very slowly on standing, it consists of sulfur and may be caused by:

(a) Too much acid in the hardener.

(b) Too little sulfite or the use of impure sulfite, in which case there is not sufficient present to protect the hypo from the acid. Loss of sulfite also occurs through oxidation if the hardener is stored in an open crock. The surface of the liquid should be protected from the air by a floating cover of Kodaloid or preferably the hardener should be stored in an air-tight vessel.

(c) High temperature. The hardener should only be added to the hypo solution when at room temperature. If the temperature of the acid fixing bath is over 85° F., it will not remain clear longer than a few days even when mixed correctly. The only remedy is to throw the sulfurized bath away and mix fresh solution as required.

If a sulfurized bath is used, the sulfur is apt to be precipitated in the gelatin, and later may cause fading of the image.[2]

2. If the precipitate is white and disappears on standing for a few hours, and a gelatinous sludge of aluminium sulfite settles out, it may be caused by:

(a) Too little acid in the hardener. For example, supposing a formula calls for pure glacial acetic acid and 28% acid is used by mistake, then less than one-third the required amount has been added.

(b) Too little hardener in the fixing bath. Also, a fixing bath with the correct proportion of hardener, when exhausted, still contains alum and sulfite but no acid, and these combine to form a sludge of aluminium sulfite.

It is extremely important, therefore to use only the acid specified and to know its strength, because trouble is caused if either more or less acid is used than is called for in the formula.

Other acids than acetic are not generally to be recommended. Mineral acids, such as sulfuric are too strong, while other organic acids such as citric, tartaric, etc., can be used only under certain very limited conditions, since they interfere with hardening.

B. The Bath Does not Harden Satisfactorily: Insufficient hardening may be a result of (1) the use of inferior alum which does not contain the correct proportion of aluminium sulfate. (2) The presence of too much acid or sulfite, or an insufficient quantity of alum. On varying the proportions of acid, alum, and sulfite, in a fixing bath, it has been found that the hardening increases as the quantity of alum increases. With increasing quantities of acetic acid with a given quantity of alum, the hardening increases to a maximum beyond which the hardening decreases. A certain minimum quantity of acetic acid, however, is necessary to give the fixing bath a fairly long useful life before aluminium sulfite precipitates but this quantity is usually greater than the quantity which produces maximum hardening. With use, therefore, the hardening ability of correctly compounded fixing baths at first increases with the addition of developer to a maximum beyond which the hardening falls off rapidly.

C. Blisters. When the sodium carbonate of the developer is neutralized by the acid in the fixing bath carbon dioxide gas is evolved which produces blisters if the gelatin is too soft to withstand the disruptive action of the gas. If the fixing bath contains an excess of acid and the films are not rinsed sufficiently, or if a strongly acid rinse bath is used, blisters are apt to be formed. On dry film blisters appear as tiny crater-like depressions when examined by reflected light. This trouble is more likely to occur in hot weather, and especially when the bath is not hardening sufficiently.

D. Dichroic Fog. If the fixing bath does not contain acid or if it is old and exhausted and contains an excess of dissolved silver salts, a stain called dichroic fog is sometimes produced on the film. In reflected light, film stained in this way looks yellowish-pink. Dichroic fog never occurs in a fresh acid fixing bath or if the film

is rinsed before fixing and the temperature of the bath is kept at 65° to 70° F.

E. Scum on Fixing Baths. When a partially exhausted fixing bath is allowed to stand several days without use, the hydrogen sulfide gas usually present in the air reacts with the silver thiosulfate in the bath and forms a metallic-appearing scum on the surface of the solution. This scum consists of silver sulfide and should be removed by drawing the edge of a sheet of blotting paper across the surface of the bath, or by using a skimmer made of several strips of cheese cloth stretched over a wire frame.

F. Stains. Several different types of stains such as white aluminium sulfite stains, sulfur stains, and yellow silver stains are occasionally produced. For a complete discussion of fixing bath stains, reference should be made to an article on this subject.[3]

REFERENCES

1. A Non-turbid Fixing Bath Containing Alum by A. Lainer. *Phot. Korr. 26*: 311 (1889).

2. Stains on Negatives and Prints by J. I. Crabtree. *Amer. Ann. Phot. 25*: 204 (1921); *B. J. Phot. 68*: 294 (1921).

3. Chemistry of the Acid Fixing and Hardening Bath by S. E. Sheppard and A. Ballard. *J. Frank. Inst. 200*: 537 (1925).

4. The Development of Motion Picture Film by the Rack and Reel Systems by J. I. Crabtree. Eastman Kodak Co., Rochester, N. Y. 1927.

5. Rapid Fixing Baths by E. J. Wall. *Amer. Phot. 17*: 366 (1923).

6. Chemistry of the Acid Fixing Bath by S. E. Sheppard, F. A. Elliott, and S. S. Sweet. *J. Frank. Inst. 196*: 45 (1923).

7. High Temperature Development of Film and Paper by J. I. Crabtree. *B. J. Phot. 64*: 555 (1917).

8. On Convection Effects in Photographic Bathing Operations by E. R. Bullock. *B. J. Phot. 69*: 110 (1922); *Amer. Phot. 16*: 162 (1922).

9. The Fixation of Photographic Plates by A. Lumière and A. Seyewetz. *Bull. soc. franc. phot. 11*: 66 (1924).

10. The Time of Fixation by C. Welborne Piper. *B. J. Phot. 60*: 59 (1913).

11. *Investigations on the Theory of the Photographic Process* p. 123, Longmans, Green & Co., London.

12. The Fixing Bath and Time of Fixation by P. Strauss. *Phot. Ind.* 911 (1925).

13. Fixing Baths and their Best Utilization by E. Lehmann and L. Busch. *Kinotech, Jahrbuch* p. 114 (1925-1926).

14. The Recovery of Silver from Exhausted Fixing Baths by J. I. Crabtree and J. F. Ross. *Amer. Ann Phot. 44*: 159 (1927).

15. *Chimica Fotograica* by R. Namias p. 431, Il. progresso fotografico, Milan (1912).

16. The Behavior of Gelatin in the Processing of Motion Picture Film by S. E. Sheppard. *Trans. Soc. Mot. Pic. Eng. XI*: No. 32, 707 (1927).

17. Handling and Mixing Photographic Chemicals and Solutions by J. I. Crabtree and G. E. Matthews. *Photo-Miniature* Nos. 200-201, Tenant and Ward, N.Y. (1927).

18. Graininess of Motion Picture Film by J. I. Crabtree. *Trans. Soc. Mot. Pict. Eng. XI*: No. 29, 77 (1927).

19. The Handling of Motion Picture Film at High Temperatures by J. I. Crabtree. *Trans. Soc. Mot. Pict. Eng.* No. 39 (1924).

SOME PROPERTIES OF FINE-GRAIN DEVELOPERS FOR MOTION PICTURE FILM*

H. C. Carlton and J. I. Crabtree

SINCE the publication of the Kodak fine-grain developer formula for motion picture film[1] many requests have been received for further details pertaining to its use, and for methods of altering its photographic characteristics. Experience has shown that the developer cannot be exhausted to the same degree as many developers which have been used previously because it is more sensitive to the retarding action of the products of development. Also a black sludge of metallic silver forms in the developer during its use, and with an exhausted developer an excess of sludge is present which tends to deposit on the negative.

The present work was undertaken in order to investigate:

(a) The useful life of the borax developer during which no appreciable loss in the speed of the emulsion is incurred.

(b) Methods for maintaining the rate of development constant for use in machine development.

(c) Methods for increasing or decreasing the rate of development to satisfy the requirements of the various film laboratories.

(d) Methods of obtaining finer-grained negatives.

I. Methods of Measuring the Photographic Characteristics of the Developer

General methods of testing photographic developers have been described by one of the authors.[2] These general methods supplemented by those described below, were used.

A. Method of Development

Development was carried out in exactly the same manner as recommended for the development of motion picture film by the rack and reel systems.[3] All the data on mixing, exhaustion, and revival were obtained from the use of a 120-gallon tank of developer employed in the routine way for commercial work.

* Communication No. 388 from the Kodak Research Laboratories, Rochester, N. Y.

A miniature duplicate of the commercial rack and tank apparatus was used for testing and exhausting the experimental developers. Glass battery jars holding one-half gallon of developer were kept at a constant temperature by circulating tempered water around them. Small racks were used holding 50 inches of motion picture film and were constructed like the racks used in regular motion picture work. Checks were made at frequent intervals to insure conditions corresponding to those found in commercial practice.

A standard manipulative treatment was given in all cases as follows: The rack was agitated by lifting about two-thirds of the way out of the developer. To start the development, the lower cross bar was just dipped under the solution and then wiped under the solution with a general sweeping motion of the hand to remove airbells.[4] The upper part of the rack was next immersed and the top cross bar wiped in the same way, the whole immersion procedure taking no more than five seconds. The rack was then gently moved with a circular motion in the developer, and agitated at the end of 45 seconds and again at the end of every minute until development was complete.

B. Sensitometry

Most of the sensitometric measurements were made with Eastman motion picture panchromatic negative film (type 2). One emulsion was chosen and used for the tests on the various developers so that all the tests were comparative.

The standard sensitometric method of Hurter and Driffield was employed. This method is described in detail by Jones and Crabtree.[5]

The sensitometer for making the standard exposures was similar to that described by Jones.[6] The exposures were produced by a single revolution of a sector wheel which gave nineteen exposures differing by the factor of the square root of two. The light source was an acetylene burner screened to noonday sun with a No. 79 Wratten filter.

In studying the characteristics of a developer, a series of strips exposed upon the sensitometer were developed for 6, 9, 12, 15, 18, and 21 minutes. When the characteristic H. & D. curves were plotted, a family of curves was obtained as shown in Fig. 1. These curves illustrate the effect, on the characteristics of the negative,

of increasing the time of development. With increased time of development the densities in the highlights at *R* increase much faster than the shadows at *L* and give a corresponding increase in the density contrast of the negative.

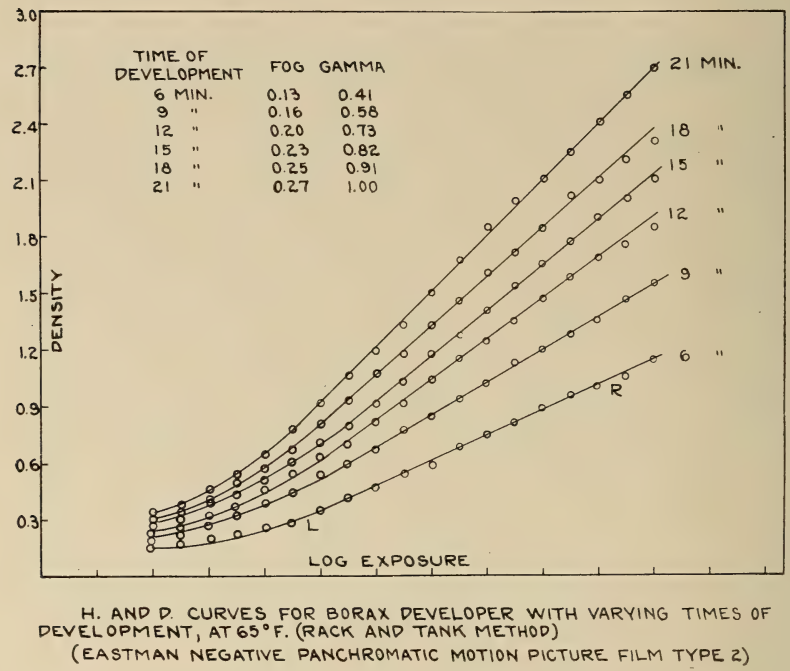

FIGURE 1. H. & D. Curves for Borax Developer with varying times of development at 65°F. (Rack and Tank Method). (Eastman Negative Panchromatic Motion Picture Film Type 2)

Each of the curves has a straight line portion and the angle made at the intersection of this extended straight line with the exposure axis is a measure of the degree of development. This angle increases with the time of development. The tangent of this angle affords a numerical measure of the amount of development and is called the development factor or *gamma*.

In the lower exposure region which corresponds to the shadows at *L*, each of the curves deviates from the straight line and becomes more nearly parallel to the exposure axis. This portion of the curve is called the *underexposure region* of the characteristic curve in contrast to the straight line portion which is called the *region of*

correct exposure. This underexposure region is often called the *toe* of the curve and extends up to the point where the density values begin to lie on a straight line. The shape of the toe is very important in reproduction because the extreme shadows in most normally exposed negatives and nearly all of the tones of an underexposed negative may fall on this portion of the curve.

The density contrast of the negative is the density difference between the extreme highlights and the extreme shadows and depends on both the brightness contrast of the subject and the degree of development. Although *gamma* and *contrast* of the negative do not have the same meaning, they are proportional when the exposure of the negative remains constant. Low gamma development gives a flat negative with low density contrast and high gamma gives a negative with high contrast.

C Fog Measurement

The fogging action of developers has been discussed by Crabtree[7] and by Dundon and Crabtree.[8] The fogging action varies greatly with the nature of the developer and is measured as the density of the deposit on an unexposed portion of the film, such as the area outside of the perforations on a strip of motion picture negative. Normal fog densities range from 0.10 to 0.25.

D Speed of Emulsion

It is customary to specify the *speed* or sensitivity of a photographic material in terms of the exposure value (inertia) where the straight-line portion of the H. & D. curve extended cuts the exposure axis.[5] This, however, is not a true indication of the relative density-giving power of the emulsion when exposed to light of different colors or wave-lengths. Methods of determining relative speeds to various portions of the spectrum have also been outlined previously.[5]

When discussing relative speed values, the cameraman is primarily concerned with the ability of an emulsion to render detail in the deep shadows with an underexposure. This property can be numerically evaluated for some emulsions by a study of the characteristic curve. A line is drawn through the plotted fog values and parallel to the exposure axis. The straight-line portion of the curve is then extended to cut this line and the exposure value at this intersection may be considered as a measure of the *speed* of the

emulsion. For a faster film the exposure value is smaller so that the *reciprocal of the exposure value* gives a numerical value of the speed of the emulsion. This makes a fairly accurate method for numerically evaluating the shadow rendering power as long as a constant degree of development is used, and the straight-line portion of the curve extends down to density readings of 0.3 to 0.4. In other words, this method holds when the characteristic curve for the emulsion does not have a long underexposure region.

With some emulsions the toe of the curve is relatively long and rounded up to a density value of 1.0. In this case the projection of the straight-line portion above a density value of 1.0 is not an accurate measure of the speed of the emulsion. A method has been described by Jones and Russell[9] for evaluating the speed of such an emulsion in terms of the *minimum useful density gradient.* For this purpose the point is taken on the curve where the tangent has a value of 0.2 and the point of intersection of this tangent with the line drawn through the plotted fog value and parallel to the exposure axis is a measure of the speed of the emulsion. With emulsions which have long rounded toes, this method is far more indicative of the speed of the emulsion for the cameraman than the standard method outlined above.

The speed measurements made in this investigation were made with an emulsion which had a very short toe so that the speed measurements calculated from the inertia value were a fairly true measure of the speed of the emulsion for the cameraman.

II Photographic Characteristics of the Fresh Borax Developer

A Characteristic H. & D. Curves

Typical H. &. D. curves for Eastman motion picture panchromatic film (type 2) developed for varying times in the borax developer are shown in Fig. 1. When the exposures are within the limits on the exposure axis that correspond to the straight-line portion of the curve, correct reproduction is obtained. When a subject is underexposed, part of the exposures fall in the region of the toe and correct reproduction is not obtained.

Similar H. & D. tests were made with the MQ-80 tank developer[3] which has a much higher rate of development. The borax developer gave more emulsion speed for the higher degrees of development. For a low degree of development the curves were prac-

tically identical. The development of detail in the toe part of the curve with the MQ-80 developer is inhibited by the potassium bromide which is used to prevent the developer from giving excessive fog.

B Time-Gamma Curves

Examination of Fig. 1 shows that the extent of development or contrast of the negative increases with the time of development. This relation between the contrast and time of development, which is a fundamental characteristic of every negative developer, is recorded by plotting the time of development against the gamma. (The gamma is the tangent of the angle made by the intersection of the extension of the straight-line portion of the curve with the exposure axis.) Fig. 2 gives *time-gamma* curves for four different temperatures including one above and two below the usual development temperature, 65° F.

The gamma value for a constant time of development is a measure of the rate of development. Examination of Fig. 2 shows that when developing for 15 minutes an increase in the temperature of the developer from 55° F. to 75° F. increases the rate of development indicated by a rise in gamma from 0.68 to 0.96.

The rate of development and the shape of the time-gamma curve depend upon the method of development used. A comparison was made of the relative rates of development with rack and tank, with reel, and with brush development. Brush development gives maximum agitation of the developer and removal of the oxidation products from the surface of the developer and approximates the rate of development obtained by machine methods. Results are given in Table I for the rate of development obtained by these three methods.

TABLE I

Effect of Agitation on Rate of Development

Treatment	*6 Min.* Gamma	*9 Min.* Gamma	*12 Min.* Gamma	*15 Min.* Gamma	*18 Min.* Gamma	*21 Min.* Gamma
Rack and tank	0.41	0.58	0.65	0.83	0.91	1.00
Reel development	0.54	0.77	0.95	1.03	1.11	1.20
Brush development	0.57	0.79	0.97	1.07	1.13	1.23

The brush and the reel methods give practically the same rate of development and correspond with the maximum agitation that can be produced under practical conditions. Over the range tested

the rack method takes about three minutes longer to produce the same degree of development than the other methods. All the data on rate of development recorded were obtained by the rack and tank method unless otherwise stated.

To interpret correctly the data represented by the time-gamma curves, it is necessary to know the gamma that is used in current practice and the limits in terms of gamma for flat and contrasty development. It was found necessary to determine the degree of development in current use in the commercial film laboratories. Sensitometrically exposed strips of film were sent to nine of the film laboratories in Hollywood, Calif., and developed under normal processing conditions. The gamma values varied from 0.44 to 0.70 with most of them falling in the range from 0.55 to 0.65. H. & D. strips were developed together with a large number of customers' negatives taken outdoors that were developed by judgment in the Eastman laboratory, and these gave an average gamma value of 0.80. This higher gamma value is necessary in the case of commercial negatives taken under average conditions on the eastern part of the United States because the brightness contrast of the objects photographed outdoors is not so great as that prevailing in Hollywood.

The maximum gamma that can be obtained depends upon the nature of the emulsion used, the developer, and the method of development. For Eastman motion picture panchromatic negative film (type 2) with the borax developer and the rack and tank method, the maximum gamma is 1.4. Since the average gamma of studio negatives is around 0.65, it is seen that ample contrast is obtainable with the borax developer.

In the study of developer formulas it is necessary to consider the fog produced as well as the rate of development. The three curves at the bottom of Fig. 2 show the fog values for the borax developer for three different development temperatures.

C. Watkins Factor

Some workers, who develop negatives by judgment, observe the negative during the early stages of development and determine the time of appearance of the first trace of image. The factor by which this time must be multiplied to give the desired time of development for a normal negative is called the *Watkins factor.* Tests have been made with various types of negatives in fresh and used fine-

TABLE II

Effect of Variations in Composition on the Properties of the Borax Developer Constituents of Developer

Expt. No.	Grams per Liter					Gamma						Data at Gamma of 0.7		
	Elon	Hydro-quinone	Sodium Sulfite	Borax	Potassium Bromide	6 Min.	9 Min.	12 Min.	15 Min.	18 Min.	21 Min.	Relative Speed	Fog	pH
1	2	5	100	2		0.41	0.58	0.73	0.82	0.91	1.00	530	0.20	8.5
2	2	5	100	2	0.1	0.38	0.52	0.67	0.76	0.85	0.94	740	0.18	8.5
3	2	5	100	2	0.5	0.37	0.51	0.66	0.74	0.84	0.91	646	0.16	8.5
4	2	5	100	2	1.0	0.34	0.48	0.62	0.72	0.80	0.86	450	0.15	8.5
5	2	5	100	2	2.0	0.33	0.44	0.54	0.65	0.75	0.82	412	0.15	8.5
6	2	5	100	2	5.0		0.35	0.44	0.56	0.66	0.71	150	0.08	8.5
7	4	5	100			0.35	0.52	0.67	0.76	0.85	0.93	635	0.13	7.8
8	4	5	100	2		0.43	0.60	0.71	0.80	0.90	0.98	660	0.15	8.1
9	4		100			0.35	0.50	0.61	0.71	0.80	0.86	590	0.15	7.9
10	2	5	100	20		0.72	0.92	1.03	1.11	1.20		550	0.16	9.2
11	2	5	100	6		0.53	0.72	0.89	0.98	1.04		575	0.20	8.9
12	2	5	100			0.31	0.47	0.60	0.67	0.73		490	0.18	8.1
13	2		100			0.31	0.48	0.60	0.67	0.74	0.78	560	0.15	8.3
14	2		100	2		0.33	0.52	0.62	0.70	0.78	0.86	741	0.15	8.6
15	2	10	100	2		0.42	0.60	0.73	0.84	0.97	1.05	590	0.14	8.5

					Sodium Sulfite Anhydrous									
16	2	5	25	2	50	0.32	0.47	0.60	0.70	0.77	0.82	513	0.19	8.3
17	2	5	50	2	50	0.37	0.54	0.67	0.75	0.83	0.88	540	0.19	8.4
18	2	5	100	2	50	0.29	0.50	0.67	0.75	0.80	0.87	500	0.18	8.5
					Hypo									
19	2	5	25	2	1	0.32	0.41	0.55	0.64	0.74		390	0.14	8.4
20	6		100	6		0.55	0.71	0.85	0.93	0.98	1.06	660	0.15	8.3
21		10	100	20				0.28	0.37	0.53	0.67	360	0.16	9.2
					Potassium Bromide									
22	1	2.5	50	1		0.32	0.46	0.54	0.64	0.67	0.75	670	0.20	8.7
23	1	2.5	100	1		0.34	0.47	0.57	0.64	0.73	0.80	780	0.19	8.8
24	1	2.5	100		1	0.26	0.37	0.51	0.61	0.70	0.77	427	0.11	8.8
25	1	2.5	150	1		0.29	0.40	0.50	0.60	0.68	0.73	690	0.17	8.9
26	2	5	25	2		0.38	0.55	0.67	0.73	0.80		468	0.17	8.3
27	2	5	50	2		0.37	0.59	0.70	0.81	0.90	0.95	692	0.16	8.4
28	2	5	100	2		0.41	0.58	0.73	0.82	0.91	1.00	530	0.20	8.5
29	2	5	150	2		0.33	0.50	0.62	0.72	0.80	0.88	676	0.14	8.7
30	2	5	200	2		0.26	0.36	0.47	0.60	0.67	0.76	646	0.17	8.7

grain developers and the Watkins factor has been found to be 8.0 for a gamma of 0.7.

D. Variations of Properties with Methods of Mixing

In some preliminary experiments, variations were found in the rate of development for different batches of the same developer. A test was made to determine the effect of varying the mixing temperature. One developer was compounded[10] with water at room

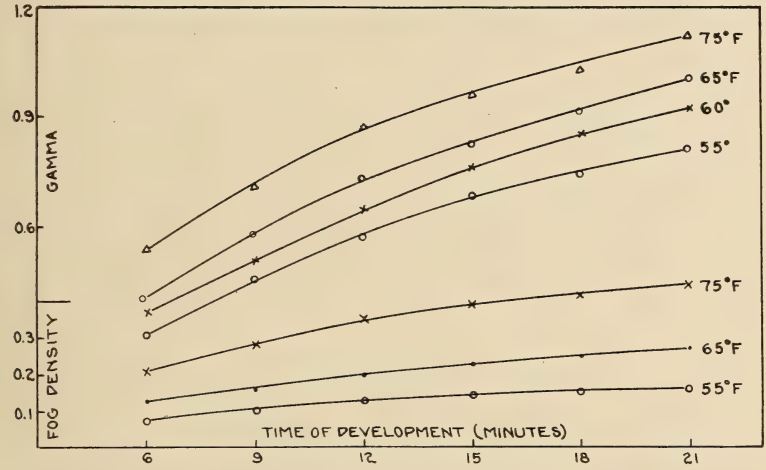

FIGURE 2. Time-Gamma and Time-Fog Curves for Borax Developer at Different Temperatures. (Rack and Tank Method). (Eastman Negative Panchromatic Motion Picture Film, Type 2).

temperature (65° F.) and another with water at 180° F. Both developers gave the same rate of development. From this it was concluded that the early variations were due to errors in compounding the developers. It is necessary to exercise great care in weighing out the correct quantity of borax because the borax developer is very sensitive to slight changes in alkalinity. In a very dry climate, borax should be stored in a closed vessel to prevent any loss of the water of crystallization.

E. Function of the Constituents of the Borax Developer

1. DEVELOPING AGENTS. Elon is the principal reducing agent and is responsible for starting the development of the negative. The hydroquinone helps to build up the heavy densities, but if

used alone, it does not have sufficient reducing power to start the development. If development is started in an Elon developer, however, it can be completed with one containing only hydroquinone as the reducing agent.

2. Sodium Sulfite. This salt is an organic reducing agent and protects the developing agents from oxidation by the oxygen absorbed from the atmosphere. Its solubility in the developer formula is such that the concentration of sulfite can be increased from zero to more than 200 grams per liter. An increase in concentration above 100 grams per liter slightly decreases the rate of development partly because of its solvent action upon the silver halide in the emulsion. This solvent action is of the utmost importance from the standpoint of graininess and will be discussed later.

3. Borax. This chemical is used because it is a very mild alkali and gives a developer with very low alkalinity when used with a mixture of Elon, hydroquinone, and sodium sulfite.

F. Effect of Varying the Concentration of the Developer Constituents

The rate of development, speed of emulsion, fog, graininess, etc., produced by the borax developer can be altered by changing the relative concentrations of the constituents used in the developer and by the addition of other chemicals such as potassium bromide, hypo, and sodium sulfate. Several experimental developers were compounded in an attempt to decrease the rate of development without decreasing the speed of the emulsion or increasing the fogging action. The tests were made with a small developing apparatus, but with the same technic as used in commercial work. H. & D. curves were made for the various development times and the gamma values determined as shown in Table II. The fog values and Eastman speed are given for a gamma value of 0.70. The same roll of Eastman panchromatic negative film was used for all of the tests. The type of H. & D. curve obtained with this emulsion is shown in Fig. 1. The developers are arranged roughly in the order in which they were tested and in terms of the extra constituents which were added.

1. Effect of Varying the Concentration of the Developing Agents. It is possible to double the concentration of Elon and hydroquinone in the regular borax formula. This increase produces

a solution which is so near the saturation point with respect to these chemicals that it is not of practical interest.

The Elon content alone can be doubled but this produces no appreciable increase in the rate of development because the effect of the Elon is offset by the decrease in alkalinity (Nos. 1 and 8, Table II). The effect that can be produced by an increase in the borax content will be discussed under "alkalinity."

When Elon is used without hydroquinone with two grams of borax per liter the concentration can be increased to 16 grams per liter. An increase above 4 grams per liter produces very little increase in the rate of development because very little of this is converted to the Elon base which is the active form. If borax is added to convert the Elon into the Elon base, the rate of development increases with the Elon concentration. The gamma produced for a constant time of development increases as a linear function of the logarithm of the Elon concentration.

If the Elon is omitted, the hydroquinone concentration can be increased to 15 grams per liter, but the resulting developer has very little developing power. A fair rate of development can be obtained with 10 grams of hydroquinine in the absence of Elon if the borax content is increased to 20 grams per liter (No. 21, Table II).

The quantity of Elon and hydroquinone can be reduced to decrease effectively the rate of development. If the quantity of borax is also reduced to 50 per cent (see No. 23, Table II), a developer with the following formula is obtained which gives a still greater decrease in the rate of development.

	Metric	*Avoirdupois*
Elon	1.0 gram	1.0 lb.
Hydroquinone	2.5 grams	2.4 lbs.
Sodium sulfite (anhydrous)	100.0 grams	100 lbs.
Borax	1.0 gram	1 lb.
Water to make	1.0 liter	120 gal.

A comparison of the time-gamma curves for this developer (B) and the regular borax developer (A) is given in Fig. 3. This developer can be used very effectively for machine development when the construction of the machine demands a developer that is slower than the regular formula and when fresh developer can be added sufficiently fast to compensate for the depletion of the developing agents.

2. Effect of Varying the Alkalinity. The alkalinity of a developer may be expressed in terms of the pH value which is the logarithm of the reciprocal of the hydrogen ion concentration, viz.:

$$pH = \log \frac{1}{C_H}$$

where CH is the concentration of hydrogen ions in the solution.[11] The absolute accuracy of the pH values is open to question, but the measured relative values have been correlated very satisfactorily

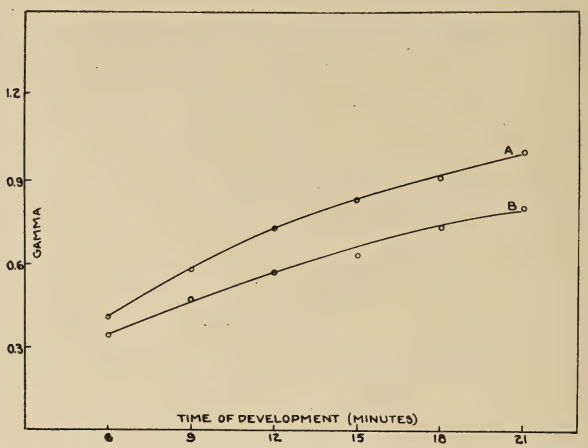

Figure 3. Time-Gamma Curves for the Regular Borax Developer (A) and with Half Concentration of Borax and Developing Agents (B). (Rack and Tank Method at 65°F.)
(Eastman Negative Panchromatic Motion Picture Film, Type 2).

by a study of the rate of development of experimental developers. Solutions with pH values about 7.0 are alkaline and the alkalinity increases with the pH value. Slightly alkaline developers like the present borax developer lie in the pH range from 8.0 to 9.0 and the more alkaline developers like sodium carbonate and caustic alkaline developers lie in the range from 11 to 14.

The pH values were determined by the LaMotte hydrogen ion apparatus which works upon the principle of color change of organic indicator dyes and when used for this purpose may be in error by $\pm$ 0.1 pH. Developers from Nos. 1 to 6 indicate that the potassium bromide content has no effect on the alkalinity but the alkalinity increases with the borax content and decreases with increased Elon content. The addition of hydroquinone decreases the alkalinity but

Elon and borax produce about an equal effect, weight for weight, the former to decrease and the latter to increase the alkalinity of the developer.

The data on the molecular weights of borax and Elon check the above results. Borax (mol. wt. = 381) is dibasic when neutralized by strong acids and is neutralized by one molecule of sulfuric acid. Elon crystallizes with one-half mole of sulfuric acid per molecule so that two molecular weights of crystallized Elon (mol. wt. = 172, total weight 344) are required to neutralize one mole of the borax. Consequently, borax and Elon neutralize each other in weight ratios of 381:344, which substantiates the result obtained from a study of the alkalinities of the developer.

In these terms the borax developer formula is simplified as it actually occurs in solution. The borax and Elon, used in equal concentration (2 grams of each per liter), practically neutralize each other so that the developing solution is essentially a solution of Elon base (monomethyl para-amino phenol) and hydroquinone in a 10% solution of sodium sulfite.

The alkalinity of the developer can be increased by increasing the quantity of borax. Fig. 4 gives time-gamma curves for the regular formula with increasing concentrations of borax up to 20 grams per liter and shows graphically how the rate of development

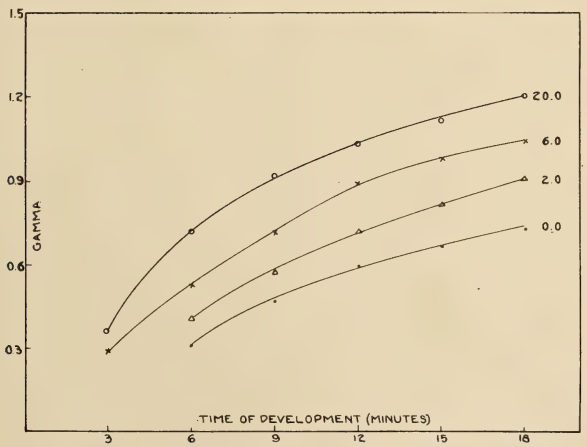

FIGURE 4. Time-Gamma Curves for Increasing Quantities of Borax in the Regular Formula at 65°F. The Borax Content is Given in Grams per Liter. (Rack and Tank Method).
(Eastman Negative Panchromatic Motion Picture Film, Type 2).

increases with an increase in borax content. If a gamma of 0.9 can be produced in 18 minutes with the regular formula, the same gamma can be obtained in 12½ minutes in a formula containing 6 grams of borax per liter; and in 9 minutes with 20 grams of borax per liter.

A definite control of the alkalinity of the developer can be maintained by adding boric acid and extra borax to the regular borax developer formula. This combination of a weak acid and its sodium salt in the same solution produces a *buffer solution,* so-called because it stabilizes the alkalinity of the solution. A buffered solution has a potential resistance to chemical agencies which tend to increase or decrease the alkalinity of the developing solution. Since the rate of development changes very much with small changes in alkalinity, the buffered solution tends to stabilize the rate of development.

By using 8 grams of boric acid with 8 grams of borax in the standard formula and then increasing one at the expense of the other, so that the total quantity of the two is kept constant, the alkalinity of the solution and the rate of development can be controlled. The variations in rate of development that can be produced by this method are shown in Fig. 5. With 14 grams of boric acid and 2 grams of borax per liter, a low rate of development is obtained, while with 14 grams of borax and 2 grams of boric acid, a high rate of development is obtained. All degrees of development between these limits can be obtained by interpolating the data in Fig. 5. Neither borax nor boric acid should be used to the exclusion of the other because, if this is done, the solution loses part of its buffering action.

Table III shows the effect, on the rate of development, of changing the concentration of borax and boric acid in the borax developer. Concentrations are given in grams per liter of borax and boric acid added to a solution containing 2 grams of Elon, 5 grams of hydroquinone, and 100 grams of sodium sulfite per liter.

3. Effect of Addition of Potassium Bromide. Comparison of developers Nos. 1 to 6 (Table II) with a potassium bromide content from 0.1 to 5.0 grams per liter shows that increasing the bromide concentration decreases the amount of development, the fogging action, and the speed of the emulsion. The lowest concentration of bromide gives a slight increase in speed because the fog

values are decreased without an appreciable decrease in the general development.

4. Effect of Variation of Sulfite Content. On increasing the concentration of sulfite from 25 to 100 grams per liter, the rate of development and the speed of the emulsion are slightly increased. Further additions of sulfite decrease the rate of development but the emulsion speed is not affected (Nos. 26-30, Table II). The influence of sulfite on graininess will be discussed later.

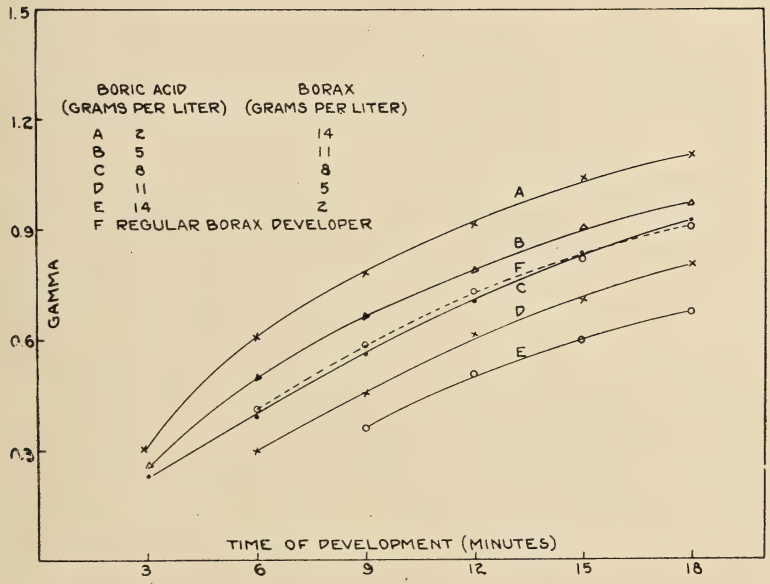

Figure 5. Time-Gamma Curves for Various Proportions of Borax and Boric Acid in the Regular Borax Developer Formula at 65°F. (Rack and Tank Method).

(Eastman Negative Panchromatic Motion Picture Film, Type 2).

5. Effect of Addition of Sodium Sulfate. Hydrated sodium sulfate has been added to tropical developers to decrease the swelling of the gelatin and the rate of development.[12] Up to a concentration of 100 grams per liter, it decreases the rate of development without decreasing the speed of the emulsion or increasing the fogging action (Table II, Nos. 16, 17, 18). Various quantities can be added to the modified developer recommended above to further decrease its rate of development.

TABLE III

The Gamma and Fog Produced with Varying Concentrations of Borax and Boric Acid in the Buffered Borax Developer

Grams per Liter Borax	*Grams per Liter Boric Acid*	*3 minutes*		*6 minutes*		*9 minutes*		*12 minutes*		*15 minutes*		*18 minutes*		
		Gamma	*Fog*	*Gamma*	*Fog*	*Gamma*	*Fog*	*Gamma*	*Fog*	*Gamma*	*Fog*	*Gamma*	*Fog*	*pH*
2				0.41	0.13	0.58	0.16	0.72	0.20	0.82	0.23	0.91	0.25	8.5
14	2	0.31	0.10	0.60	0.15	0.78	0.22	0.91	0.28	1.03	0.35	1.10	0.38	8.9
11	5	0.26	0.07	0.50	0.14	0.66	0.19	0.79	0.20	0.90	0.30	0.97	0.33	8.7
8	8	0.23	0.07	0.39	0.09	0.56	0.13	0.70	0.16	0.83	0.18	0.92	0.20	8.3
5	11			0.30	0.05	0.45	0.11	0.61	0.12	0.70	0.15	0.80	0.16	8.0
2	14					0.36	0.06	0.50	0.09	0.59	0.10	0.67	0.14	7.8

6. Effect of Addition of Hypo. Comparison of developers Nos. 19 and 26 (Table II) shows the effect of the addition of a small concentration of hypo to a modified borax developer. The addition of hypo decreases the rate of development and the speed of the emulsion. The effect of hypo on graininess will be discussed later.

7. Practical Methods of Changing the Rate of Development. The date of development can be increased by increasing the concentration of borax as shown in Fig. 4 and to a lesser degree by increasing the concentration of the developing agents if extra borax is added to compensate for their acidity.

The rate of development can be decreased by decreasing the quantity of developing agent, by decreasing the quantity of borax, by adding sodium sulfate, or by any combination of these three methods.

By using the boric acid-borax combination the rate of development can be controlled to produce any desired rate of development within the immediate range of that produced with the standard borax developer.

III. Effect of Age on the Borax Developer

A. Without Use

For commercial purposes the borax developer keeps satisfactorily when mixed in large quantities and used soon after it is prepared. It was found, however, that several samples of developers gave an increased rate of development when they were tested after having been stored for several weeks. This was caused by an increase in the alkalinity of the developer. Analytical tests showed that there was no change in the concentration of the sodium sulfite and further tests are in progress to determine the cause for the change in alkalinity.

For sensitometric purposes, however, a developer is needed whose rate of development does not change with keeping.

A comparative keeping test was made with the regular borax developer and a buffered borax developer with the following composition:

Elon	2.0 grams
Hydroquinone	5.0 grams
Sodium sulfite (desiccated)	100 grams
Borax	8.0 grams
Boric acid	8.0 grams
Water to	1 liter

The developers were stored in closed earthenware jugs and tested every week by the regular H. & D. methods. The data obtained are recorded in Table IV. The results for any time of development show that with the regular borax developer the rate of development increased with keeping. The gamma for 12 minutes' development increased from 0.78 to 1.19 in 49 days. With the buffered developer the rate of development remained constant within the limit of error for the 49 days of keeping. For sensitometric purposes which depend upon the development factors remaining constant over a period of several weeks, the buffered borax developer is preferable to the regular formula.

TABLE IV

Effect of Aging on the Regular and Buffered Borax Developer

Days	*6 min. gamma*	*9 min. gamma*	*12 min. gamma*	*15 min. gamma*	*18 min. gamma*
			Regular Borax Developer		
0	0.50	0.67	0.78	0.92	1.05
8	.53	.74	.86	.97	1.03
14	.51	.71	.89	.96	1.08
22	.60	.73	.91	1.03	1.12
28	.53	.76	.87	1.07	1.17
35	.58	.81	.95	1.05	1.15
42	.67	.92	1.01	1.10	1.24
49	.79	.99	1.19	1.43	1.45
			Buffered Borax Developer		
0	0.44	0.61	0.78	0.90	1.04
8	.46	.62	.79	.94	1.01
14	.46	.62	.79	.94	1.01
22	.49	.61	.82	.95	1.03
28	.45	.61	.77	.90	1.06
35	.46	.68	.87	.99	1.08
42	.48	.67	.80	.96	1.08
49	.47	.65	.85	.98	1.08

A series of tests were made to find the effect of aeration upon the rate of development with the regular borax developer. The results are shown in Table V in terms of the gamma values for the various times of development.

The effect of passing carbon dioxide into the developer was to decrease the rate of development. The carbon dioxide hydrolyzed to give carbonic acid which decreased the alkalinity of the developer.

Bubbling air through the developer increased the rate of development. This fact is not readily explained, but indicates that the quantity of carbon dioxide present in the air has no perceptible effect on the rate of development.

TABLE V

Effect of Aeration on the Rate of Development

	12 min. *gamma*	*15 min.* *gamma*	*18 min.* *gamma*	*21 min.* *gamma*
Regular borax	0.72	0.80	0.92	0.97
Aerated for 5 hours	.81	.93	1.04	1.09
Bubbled with carbon dioxide for 4 hours	.15	.36	.47	.52

B. With Use

1. THE CHEMISTRY OF DEVELOPMENT. (a) During development a very complex chemical reaction takes place between the silver halide in the emulsion and the developer. In the case of a negative emulsion the silver halide may be considered to consist essentially of silver bromide which reacts with a hydroquinone developer as follows:

Silver bromide + alkali + sodium sulfite + hydroquinone = Silver + sodium bromide + hydroquinone sulfonates.

Quinone is probably an important intermediate product but it reacts at once with the sulfite to give hydroquinone monosulfonate.[13] This is a developing agent and may go through the cycle again to give hydroquinone disulfonate as a final product. Elon probably gives similar reaction products because the amino-phenols, of which Elon is a member, are very easily oxidized to quinone.

The by-products of development, sodium bromide, sodium iodide, and the disulfonates of hydroquinone which accumulate in the used developer have a retarding action on development. As development progresses, the supply of developing agents is therefore slowly used up and the products of development accumulate so that a point is finally reached where there is a serious drop in the rate of development and the speed of the emulsion. The quantity of film that can be processed before this occurs determines the life of the developer.

A partially exhausted developer, however, can be rejuvenated by the addition of a fresh supply of developing agents so that it can go through another period of usefulness before it becomes exhausted.

(b) Sodium sulfite is used in most developers to protect the developing agents from aerial oxidation. When the developer is exposed to the air, a small quantity of the sulfite is converted to sulfate which in this concentration has no effect upon the development process. Some sulfite is also used up in forming the hydroquinone sulfonates, but the quantity involved is relatively small so that the effective concentration of sulfite in the borax developer remains practically constant with use.

(c) Sodium sulfite is also a solvent for the silver bromide in the emulsion and forms a silver bromide-sodium sulfite complex salt which is soluble in developing solutions. This solvent action goes on as a side reaction during development and the silver complex is then slowly reduced or developed to metallic silver which settles out on the walls of the developing tank and precipitates in the developer as a gray sludge. This sludge formation is a secondary reaction which both depletes the supply of developing agent and adds more restraining products to the developer.

2. Effect of Use on the Rate of Development. The experimental developers were exhausted in a miniature system with racks holding 50 inches of motion picture film, and tanks holding one-half gallon of developer. The data on exhaustion and revival, however, which are given below were obtained with the developer under commercial working conditions in a 120-gallon tank. The life history of several of these developers was followed by H. & D. methods with special emphasis placed on the changes that occurred when the developer was revived. Fig. 6 shows H. & D. curves obtained by developing for fifteen minutes at various stages throughout the life of a 120-gallon tank of borax developer.

An exhaustion curve for another batch of developer is given in Fig. 7. The gamma values and relative speed values are plotted against the quantity of film processed per gallon.

During use, the supply of developing agents in the borax developer is gradually depleted as a result of the development process itself and the process of sludge formation so that obviously the rate of development decreases with use. Referring to Fig. 6, for a given exposure when developing for 15 minutes, the density dropped from 1.90 to 1.64 after processing 80 feet of film per gallon. It was then necessary to increase the development time to 18 minutes to produce the density of 1.90 produced originally in 15 minutes.

Within the useful life of the developer, the time of development required to produce a given degree of development increases from 25 per cent to 50 per cent.

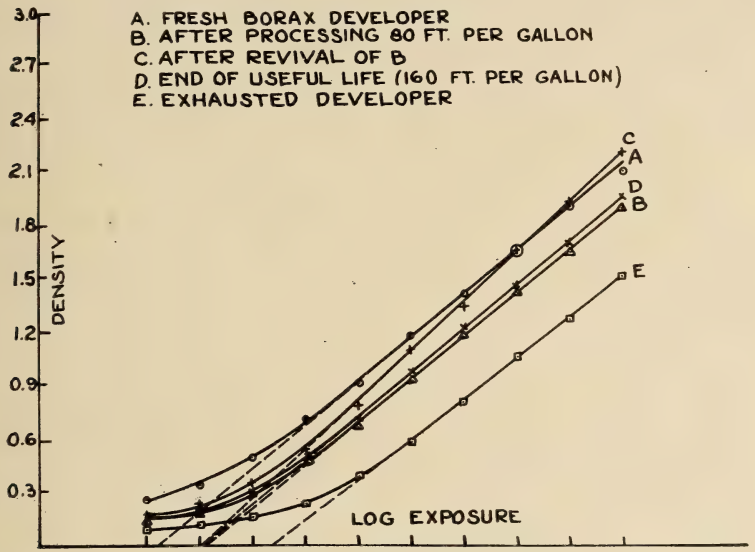

FIGURE 6. Characteristic H. & D. Curves for Fifteen Minutes Development made at Critical Points in the life of a Tank of Borax Developer. (Rack and Tank Method at 65°F.)

(Eastman Negative Panchromatic Motion Picture Film, Type 2).

The shape of the time-gamma curve is not changed by the use of the borax developer. A series of time-gamma curves corresponding to those in Fig. 2 was made with a developer in which 60 feet of film had been processed per gallon. The gamma values were lower because of the partial exhaustion of the developer but the curves had the same shape as those obtained with a fresh developer.

3. EFFECT OF USE ON THE EMULSION SPEED. It is well known that the accumulation of alkaline bromides and iodides and developer oxidation products in a developer has the same effect as reducing the speed of emulsion.[14] The extent to which an exhausted borax developer reduces emulsion speed was determined by plotting H. & D. curves throughout the useful life of the developer and with the spent developer after it was exhausted. The H. & D. curves obtained by developing for 15 minutes in fresh and exhausted developers are shown in Fig. 6. Curve A was made at the start and curve B after

80 feet of film had been processed per gallon. From curve B it is seen that the restraining products had the effect of removing or subtracting a constant density from both the highlights and shadows of the negative. Since the fog density, however, dropped from 0.22 to 0.14 there has been very little decrease in the effective emulsion speed (see also Fig. 7). The speed decreases to a value equal to about 60 or 70 per cent of initial value. Development beyond this point (80 feet per gallon) results in a much greater decrease in emul-

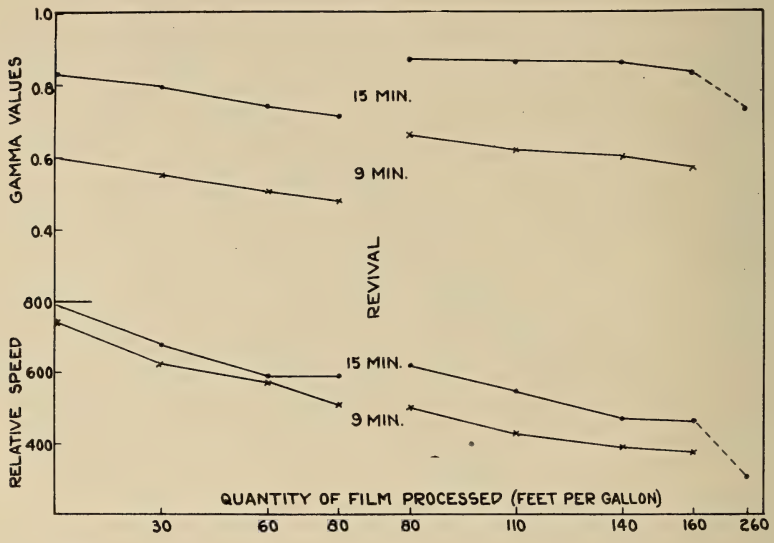

FIGURE 7. Exhauston Curves for a 120-gallon Tank of Borax Developer Showing Gamma and Relative Seed Values for a Development Time of Nine and Fifiteen Minutes (Rack and Tank Method at 65°F.).
(Eastman Negative Panchromatic Motion Picture Film, Type 2)

sion speed. Curve E indicates the condition of the developer after 200 feet of film had been processed per gallon and shows that the film speed is only 30 per cent of its original value.

The accumulation of the alkali bromides is partially responsible for the drop in the film speed shown in Curve E but no satisfactory method is known for removing them from the developer.

Further tests were made to determine if any of the usual developer constituents could be added to bring back the speed of the emulsion to its original value in the fresh developer. Borax, Elon, hydroquinone, sodium hydroxide, sodium carbonate, and potassium

carbonate were added to a developer in which 40 feet of motion picture film per gallon had been processed. Most of them gave no practical increase in film speed and some of them gave a decrease in speed. Four grams of borax per liter added to an exhausted developer increased the speed of the film by about 50 per cent. Further tests are in progress to determine if there is a practical method of increasing the life of the developer.

4. Effect of Use on the Fogging Properties. The table in Fig.1 gives the fog values for fresh borax developer over a wide range of degrees of development. With use, the amount of fog decreases for a constant degree of development on account of the accumulation of bromide ions liberated by the development process. A fog value of 0.20 for a given degree of development in a fresh developer drops to 0.12 by the time 80 feet of motion picture film have been processed per gallon.

The above values are given for fresh film. Under working conditions the fog depends upon a number of factors which include: (1) the age of the film; (2) the amount of light scatter during exposure in the camera; and (3) the amount of exposure which the film may receive during handling in the darkroom. The fog density obtained in actual practice includes that caused by the developer plus the fog accumulated in the process of handling.

C. Revival of the Borax Developer

The equation representing the chemical reactions occurring during development shows that the developing agents, the alkali and sodium sulfite, are used up in the process of development, although the quantity of sulfite which is used up is relatively small. It is obvious therefore that a solution for reviving the developer should at least contain all these ingredients. In practice it was found with the rack and tank method of development that the developer could be revived by adding half the original quantity of Elon, hydroquinone, and borax, together with a small quantity of sulfite after 80 feet of film per gallon had been processed. These were dissolved in as small a volume as possible of a 10 per cent sodium sulfite solution before adding to the developer.

Curve C (Fig. 6) shows the effect of such revival. (Compare with curve B.) The condition of the developer after 160 feet of film had been processed is shown by curve D. (See also Fig. 7)

The four curves, A, B, C, and D (Fig. 6) show that 160 feet of film can be processed satisfactorily per gallon of borax developer if it is properly revived at intervals. The revived developer gives the same gamma in a given time of development as the original developer while the emulsion speed at this exhaustion point is fully 60 per cent of the original.

Tests were made by adding increasing quantities of potassium bromide to a fresh developer and measuring the speed loss. It was found that about 1.5 grams per liter of potassium bromide were required to reduce the speed of the emulsion to 60 per cent of its original value. This content of potassium bromide corresponds with the quantity of bromide present in the exhausted developer as determined by analysis. The quantity of potassium bromide present was determined as follows: The sodium sulfite and developing agents were oxidized in alkaline solution with sodium peroxide and ammonium persulfate. After acidifying, the bromide was precipitated with excess silver nitrate and the excess silver titrated with potassium thiocyanate with ferric nitrate as an indicator. This analysis showed a content of 1.6 grams of potassium bromide per liter in a developer exhausted with 200 feet of film per gallon.

Also a determination of the quantity of bromide liberated in the developer calculated from the quantity of silver left in the developed negative shows that the equivalent of from 1.0 to 2.0 grams of potassium bromide are liberated after developing 200 feet of film per gallon, depending approximately upon the integrated density of the negative.

D. Sludging Properties of the Developer.

Sludging is a normal and unavoidable characteristic of the borax developer. The sludge is made up mostly of finely divided silver and imparts to the developer a light gray muddy appearance. An analysis of dried sludge from a used developer which contained all the foreign matter which accumulated during the processing of 160 feet of film per gallon indicated a content of 40 per cent pure silver.

With the rack and tank method of development where a tank of developer is used over a period of two weeks or longer the developer contains a considerable quantity of sludge after 160 feet of film per gallon have been processed. In the experience of this laboratory the quantity of sludge which forms has never been sufficient to interfere with successful development.

With continuous machine development the sludge may accumulate in the bottom of the tank or tubes as a result of insufficient agitation of the developer. By circulating the developer through a storage tank, most of the sludge settles out in this tank. The suspended silver can also be removed by filtering through a bed of sawdust. The sawdust for this purpose must be extracted with boiling water before use to remove the soluble constituents which might change the characteristics of the developer. The various factors which determine the amount of sludge formation are discussed later under "graininess."

IV. Graininess of Images Developed in the Borax Developer

Several investigators have studied the fine grain producing properties of the Eastman borax developer. Its ability to produce fine-grained images is undoubtedly a result of the presence of a high content of sodium sulfite which exerts a solvent action on the silver halide grains reducing their size and preventing clumping.[15] Namias[16] concludes that the rate of development is too low for practical purposes and claims that his recommended developer (formula 13, Table VI) gives equally fine-gained images with an increase in rate of development. Lumière and Seyewtz[17] found that the images produced by borax developer are finer-grained than those produced by the same developing constituents used with carbonate as the alkali. Veldman[18] concluded that the borax developer gave very fine-grained images but no finer than the following developer: Elon 15 grams; sodium sulfite (anhydrous) 150 grams; potassium bromide 2 grams; water to 1 liter. This developer is impractical because of the loss in emulsion speed caused by the high bromide content. He varied the sulfite content from 0.5 to 320 grams per liter and found that the graininess decreased as the sulfite content increased. Luppo-Cramer[19] found that with the Eastman borax developer fine-grained images were not obtained with all silver bromide emulsions. Emmermann[20] in a series of tests on motion picture film found that the Eastman borax developer was the best formula known for producing fine-grained images. Nauck[21] concludes that the low alkalinity of the borax developer contributes indirectly to the production of fine-grained images because the relatively low rate of development permits the sulfite to exert more solvent action which progresses with time. Although the normal borax developer formula gives satisfactory fine-grained images, experiments were made to determine the

possibility of securing even finer-grained images and to study the effect, on graininess, of varying the composition of the developer and the time of development.

A. Method of Measuring Graininess.

An 8½ x 11 inch sheet of Kodaloid was divided into 9 equal rectangular areas. A step tablet was made by covering the areas with pieces of neutral gray gelatin having densities ranging in steps of 0.3 from that obtained with film base (0.02) up to 2.4 inclusive. This tablet was then mounted on the easel of a title camera and illuminated from behind with the light from two 1000-watt lamps diffused with ground glass. A length of film was exposed in the camera and then used as a standard for testing the graininess produced by the experimental developers. With normal development this negative gave 9 uniform areas per frame with densities ranging from 0.15 to 1.4.

Half gallon glass battery jars were used for holding the experimental developers and four jars were handled as a unit in a constant temperature water bath. A miniature wooden rack was used holding 50 inches of standard film. To test a series of developers, one rack of the standard negative was developed to the same gamma in each of the trial developers. Each of the 50-inch negatives was spliced into a loop and a 30-foot print made from each for projection. The prints were all given the same time of development.

B. Experimental Results

A series of experimental developers was compounded in which the concentration of each of the constituents was varied over a wide range. Each was compared with the standard borax formula. The conclusions indicated in Table VI were drawn from the prints projected under normal projection conditions.

C. Discussion of Data

The following general conclusions have been drawn from a long series of graininess tests on trial developers.

1. For a constant degree of development the graininess decreases as the sulfite content of the developer increases from 25 to 200 grams per liter. In the range between 25 to 100 grams of sulfite per liter there is a marked decrease in graininess and a slight definite improvement occurs in the range from 100 to 200 grams per liter.

TABLE VI

Variations In Graininess Produced by Varying the Components of the Borax Developer

No.	*Elon*	*Hydro-quinone*	*Sodium Sulfite*	*Borax*	*Boric Acid*	*Sodium Sulfate*	*Time of Development*	*Graininess*
1	2	5	100	2	(Standard Developer)		10½ min.	Average
2	2	5	100	2	14		19 "	Very good
3	2	5	100	8	8		9½ "	Average
4	2	5	100	14	2		7 "	Poor
5	2	5	25	2			8 "	Very Poor
6	2	5	50	2			8 "	Poor
7	2	5	150	2			12 "	Very good
8	2	5	200	2			15 "	Very good
9	2	0	100	2			12 "	Average
10	0	10	100	20			16 "	Average
11	1	25	50	1			15 "	Poor
12	1	25	100	1			15 "	Very good
					Sodium Carbonate			
13*	5	0	50		5		5 "	Poor
14	2	5	100	2		100	15 "	Good
15	2	5	50	2		100	15 "	Average
16	2	5	25	2		100	15 "	Poor
					Hypo			
18	2	5	25	2	0.5		13 "	Good
17	2	5	25	2	1.0		11 "	Good
19	2	5	25	2	2.0		19 "	Good
20	2	5	25	2	4.0		28½ "	Average

* Namias developer used with 5 c.c. of phenosafranine (1: 1000) per liter.

2. If the sulfite content of the developer is maintained constant and the concentration of one of the other constituents is varied so as to alter the rate of development, the graininess for a constant degree of development decreases as the rate of development decreases. For example, if the quantity of developing agents and borax is halved so that the rate of development is decreased, the graininess decreases because, in order to secure negatives having a given contrast, development must be prolonged during which time the sulfite can exert a greater solvent action and therefore reduce the graininess.

The total solvent action of a developer on the emulsion can be increased in two ways as follows:

(a) By increasing the sodium sulfite content;

(b) By decreasing the rate of development so that the negative is in contact with the developer for a longer time and the sodium sulfite present has more time to exert a solvent action.

The solvent action, however, cannot be carried to the extreme without detracting from some of the other good qualities of the developer. A very high concentration of sodium sulfite causes an excessive quantity of the silver halide to be dissolved and this is accompanied by increased sludge formation. A badly sludged developer is objectionable because it leaves a residue on the negative which is not readily removed in the wash water and is very difficult to remove in the drying room. Moreover, the formation of sludge is a development process and not only depletes the supply of developing agents but builds up the reaction products of the developer which inhibit the process of development. Therefore, as the solvent action of a developer is increased its useful life decreases because a large percentage of the developer is wasted in the formation of sludge.

Hypo is also a solvent for the silver halides and has been used successfully in some developer formulas containing caustic alkalis. The last four tests recorded in Table VI were made to ascertain if small quantities of hypo could be used in the same way that relatively large amounts of sodium sulfite are used to produce fine-grained images. Just enough sodium sulfite was used in a developer formula to act as a preservative for the developing agents.

Hypo is a very active silver halide solvent and the concentration that can be used is critical. One gram per liter was sufficient to produce very fine-grained images. The higher concentrations, although giving satisfactory graininess, dissolved so much of the silver halide that they appreciably decreased the speed of the emulsion.

Theoretically the hypo which combines with the silver halide to form the soluble silver halide hypo complex salt should be generated when the combined silver is reduced so that the concentration of the hypo should remain constant as the developer is used. The advisability of the use of hypo in this type of developer, however, is questionable.

3. If the concentration of the developer is kept constant, the graininess decreases with the degree of development. A series of test exposures was developed at 2-minute intervals from 6 to 24 minutes. To test the relative graininess of these negatives the positive development times were varied so as to make matched prints from the high and low gamma negatives. The prints were developed in the motion picture positive developer (Formula D-16) with the following results:

TABLE VII

Negative Development Minutes	*Gamma of Negative*	*Positive Development Minutes*	*Virtual Gamma of Print*
6	0.39	8.5	0.70
16	.80	3.5	.80
8	.46	8.5	.78
18	.86	3.5	.78
10	.54	8.5	.96
24	.98	3.5	.88

As shown in the table, the prints were matched for 6 and 16, 8 and 18, and 10 and 24-minute negatives to give practically the same virtual gammas (product of gammas of positive and negative). For each pair of negative development times the higher degree of development gave more graininess than the lower one.

The above tests indicate therefore that the graininess of prints made at a constant virtual gamma is not constant but increases with the degree of development of the negative. From this it must be concluded that increasing the degree of development of the negative increases the graininess far more than increasing the degree of development of the print. In other words, the graininess-gamma curve for the negative material over the useful range of gammas (0.5 to 1.0) appears to be straight and rather steep, while the graininess-gamma curve for the positive (gammas of 1.2 to 2.2) has a long shoulder which must be almost parallel to the gamma axis. Further work is in progress in this connection.

D. Practical Applications

The proportion of sodium sulfite in the published formula for borax developer is very satisfactory for the rack and tank method of development where the same developing solution is used over a period of two or three weeks. It gives the minimum graininess that can be obtained with the quantity of sludge that can be tolerated with this type of developer.

In the case of commercial film laboratories where several tanks of developer are exhausted in one night, different conditions prevail since with the normal developer more than five hours are required for the sludge formation to take place. If the developer is exhausted quickly it is possible to use a higher concentration of sulfite and obtain finer-grained images throughout the life of a developer.

V. Use of the Borax Developer with Motion Picture Positive Film

Extensive tests have indicated that the graininess of images produced by the borax developer is not appreciably less than that of images obtained with the formula D-16 recommended for the development of Eastman motion picture positive film. In many cases, however, the borax developer is to be preferred for the following reasons:

A. It may be used with safety for developing positive film on a reel because the high concentration of sodium sulfite prevents the formation of aërial fog.[8]

B. The rate of development of positive film with the borax developer is relatively slow so that it is to be preferred when a low degree of development is required. From Table VIII it is seen that

Table VIII

Time-gamma Measurements for Positive Film Developed in the Borax and D-16 Developers by the Rack and Tank Method at 70° F.

Borax Developer		*D-16 (Elon-Hydroquinone)*	
Time	*Gamma*	*Time*	*Gamma*
11 min.	1.25	3 min.	1.0
14 min.	1.45	5 min.	1.45
17 min.	1.62	7 min.	1.72
20 min.	1.68	9 min.	1.90
23 min.	1.72	11 min.	1.93
26 min.	1.72	13 min.	1.95

a maximum practical gamma of 1.7 is obtained with Eastman positive film in 23 minutes at 70° F. as compared with a maximum gamma of 1.93 obtained in 11 minutes at 65° F. with Formula D-16.

For any given developer formula the rate of development and maximum gamma depend on the temperature of development, the nature of the emulsion used, the degree of exhaustion of the developer, and the degree of agitation of the film, so that with machine development the above maximum gammas would be somewhat higher. The rate of development may also be modified in the same manner as outlined on page 17.

Prolonged development in the borax developer beyond 20 minutes at 70°F. is not advisable owing to the fact the fine-grained positive emulsion is appreciably soluble in concentrated solutions of sodium sulfite. Unexposed positive film will fix out completely in from 60 to 90 minutes at 70°F. in the borax developer although some dichroic fog is simultaneously formed.[7]

The life of the developer with use is somewhat shorter than for negative development owing to the greater solubility of the fine-grained positive emulsion which therefore causes greater sludge formation and a relatively more rapid exhaustion of the developer. It may, however, be revived in the same manner as when used for motion picture negative film.

VI. Summary and Practical Recommendations

A. For the rack and tank method of development when one tank of developer is used over a period of two or three weeks the following formula as previously published[1] is very satisfactory:

	Metric	*Avoirdupois*
Elon	2 grams	2 lbs.
Hydroquinone	5 grams	5 lbs.
Sodium sulfite (anhydrous)	100 grams	100 lbs.
Borax	2 grams	2 lbs.
Water to	1 liter	120 gal.

About 80 feet of negative motion picture panchromatic film can be processed per gallon before the developer needs revival. During this time the fog or veil will decrease considerably, the speed of the emulsion will drop to about 60 per cent of its value in the fresh developer, and the time of development for a given contrast will increase from 20 per cent to 30 per cent.

After 80 feet of film have been processed per gallon, the developer can be revived with half the original quantities of Elon, hydroquinone, and borax dissolved in hot water with enough sodium sulfite to make its concentration in the reviving solution equal to 10 per cent. For the revival of a 120-gallon tank of the developer, one pound of sulfite and the one pound of Elon are dissolved in 2 gallons of hot water, one pound of sulfite and two and a half pounds of hydroquinone in 2 gallons of hot water, and three pounds of sulfite and one pound of borax in 2 gallons of hot water. These three solutions are added in succession to the developer tank and mixed thoroughly.

An additional 80 feet of motion picture film per gallon can then be processed in the revived developer without any serious drop in the speed of the emulsion. Further use of the developer may give a serious drop in the speed of the emulsion.

B. The graininess of images produced by the borax developer can be improved in three ways:

1. If the rate of development is held constant, the graininess for a constant degree of development can be improved by increasing the concentration of sodium sulfite to give increased solvent action.

In processing laboratories where a developer is used continually for one night and then discarded, the sulfite content can be increased to 150 grams per liter. This developer is recommended only in cases where it can be exhausted rapidly and thrown away before it has time to sludge excessively.

2. If the sulfite content of the developer is held constant, the graininess for a constant degree of development can be improved by decreasing the rate of development. This is done by decreasing the alkalinity of the developer or reducing the concentration of the developing agents.

3. The graininess of an image on negative motion picture film developed in the borax developer increases as the degree of development (gamma) of the image increases. In the case of positive motion picture film, however, graininess appears to increase as the degree of development increases up to a certain point and then increases only slightly, if at all. From the standpoint of graininess, therefore, for a given virtual gamma of the positive (product of negative and positive gammas) it is preferable to develop the negative to a relatively low gamma and the positive to a relatively high gamma.

C. In order to increase the rate of development the alkalinity

of the developer can be increased by increasing the borax content up to 20 grams per liter. An increase in the rate of development with no increase in solvent action may increase slightly the graininess of the negative.

D. The rate of development can be decreased by lowering the concentration of the Elon, hydroquinone, and borax to one-half that present in the regular formula. Such a developer will give slightly less graininess than the regular formula. It is very suitable for machine development where the rate of flow of fresh developer can be adjusted to compensate for the depletion of the developing agents. Hydrated sodium sulfate can be added in various quantities up to 100 grams per liter to reduce still further the rate of development and reduce the graininess.

E. The rate of development can be controlled by using 8 grams of boric acid and 8 grams of borax per liter in the usual formula. With a ratio of 8 to 8 the rate of development is not changed. By increasing the quantity of borax with a corresponding decrease in the boric acid content the rate of development is increased. By decreasing the borax content and increasing the proportion of boric acid the rate of development is decreased. The developers with the high concentration of boric acid have shorter useful lives because the reduction potential of the developing agent is lowered and they are more susceptible to the accumulation of reaction products of development.

F. The borax developer formula is also satisfactory for the development of motion picture positive film, but the only apparent advantages over existing developers are that it does not give aërial fog when the film is developed on a reel, while it gives a relatively low maximum practical gamma. Tests to date have indicated that the borax developer does not produce images on positive film having appreciably less graininess than those produced by existing developer formulas.

Acknowledgment

The authors are indebted to Mr. T. Gaski of this laboratory who assisted in the experimental work.

REFERENCES

1. *Eastman Duplicating Film,* published by Eastman Kodak Co., Rochester, N. Y. 2nd Edition (1927).

2. *Photographic Methods of Testing Developers,* by J. I. Crabtree, Brit. J. Phot. *69:* 153 (1922).

3. *The Development of Motion Picture Film by the Rack and Reel Systems,* by J. I. Crabtree, Eastman Kodak Co., Rochester, N. Y. (1927).

4. *Rack Marks and Air Bells on Motion Picture Film,* by J. I. Crabtree and C. E. Ives, Trans. Soc. Mot. Pict. Eng., No. *24,* 95 (1925).

5. *Panchromatic Negative Film for Motion Pictures,* by L. A. Jones and J. I. Crabtree, Trans. Soc. Mot. Pict. Eng., No. *27,* 131 (1926).

6. *A Special Sensitometer for the Study of the Photographic Reciprocity Law,* by L. A. Jones, J. Opt. Soc. *7:* 305 (1923).

7. *Chemical Fog,* by J. I. Crabtree, Amer. Ann. Phot. *33:* 20 (1919).

8. *The Fogging Properties of Developers,* by M. L. Dundon and J. I. Crabtree, Brit. J. Phot. *71:* 701-719 (1924); Trans. Soc. Mot. Pict. Eng., *12* No. 36 (1928), p. 1096.

9. *The Expression of Plate Speeds in Terms of Minimum Useful Gradient,* by L. A. Jones and M. E. Russell, Proc. Seventh Int. Phot. Congress.

10. *Handling and Mixing Photographic Chemicals and Solutions,* by J. I. Crabtree and G. E. Matthews, Photo-Miniature Nos. 200-201, published by Tennant & Ward, New York, N. Y. (1927).

11. *The Determination of Hydrogen Ions,* 2nd Edition (1925) by Wm. M. Clark, published by Williams and Wilkins Co.

12. *The Handling of Motion Picture Film at High Temperatures,* by J. I. Crabtree, Trans. Soc. Mot. Pict. Eng., No. *19,* 39 (1924); Brit. J. Phot. *71:* 462 (1924).

13. *The Action of Oxygen on Hydroquinone and Sodium Sulfite,* by J. Pinnow, Z. Wiss. Phot. *11:* 289 (1913).

14. *Theory of Development,* by A. H. Nietz, published by D. Van Nostrand Co. New York (1922).

15. *Graininess of Motion Picture Film,* by J. I. Crabtree, Trans Soc. Mot. Pict. Eng., No. *27,* 77 (1927).

16. *A Developer for Fine Grained Images,* by R. Namias, Il. prog. fot. *34:* 283 (1927); ibid. *35:* 133 (1928).

17. *A Study in Methods of Development for Obtaining Fine Grained Images,* by A. and L. Lumière and A. Seyewetz, Sci. Ind. Phot. *7A:* 107 (1927); and *8A:* 3 (1928).

18. *Fine Grained Development,* by F. Veldman, Das Atelier, *35:* 30 (1928).

19. *Inorganic Desensitizers and Fine Grained Development,* by Lüppo-Cramer, Phot. Korr. *64:* 169 (1927).

20. *The Gevaert Special Film,* by C. Emmermann, Filmtechnik, *3:* 426 (1927).

21. *Grain Size, Specific Surface and Ripening,* by W. Nauck, Kinotechnik *9:* 538 (1927).

DISCUSSION

MR. CLARK: I should like to have these things worked out in the same manner as was done by the Bureau of Standards in 1920 for various emulsions.

DR. CARLTON: I do not recall their results, but if they were made by plotting gamma versus time, they will be comparable.

MR. TAYLOR: In a specialized line or industry we fall into derivations of vernacular, and sometimes we go to the other extreme. It seems to me that it is desirable to think a little about gamma. I have had enough contact with good, practical men in the business who are interested in gamma, but they have not studied Greek, their mathematics are hazy, and logarithms scare them, but they understand it if given in another way. The speaker's talk was very clear, but can't we use something else that will be short instead of gamma. I don't know why gamma was selected, but it was pointed out that gamma is a slope. A slope is a grade, that is, a gradation, and isn't the term covered as well by "gradient" or "gradation?" If you fall into the habit of using this, won't the thing be intelligible to many men who drop out when it enters the field of mathematics?

DR. CARLTON: The word "gradation" is used in photography in another sense and would not suffice. Gamma means "slope of the straight-line portion of an H. & D. curve" and there is no single word in English which expresses this. If we change gamma to some other word it would require just as much effort to learn its meaning as it would require to understand the significance of gamma in the first place.

MR. BRIEFER: How were the graininess measurements made?

DR. CARLTON: The method is fully described in the paper. Essentially, they were made by projection on the screen of a series of areas of uniform density ranging from 0.3 to 1.5. The distance from the screen at which non-homogeneity of the most grainy area disappeared was taken as a measure of the graininess. The test tablet was obtained by photographing, by transmitted light, a series of squares of neutral density film, arranged as a checker board. A constant exposure was given throughout. The exposed test strips were then developed in the various developers to a constant gamma, and matched prints made by developing the positive to a constant gamma and varying the exposure when necessary.

In the case of average positive prints, grainness is most apparent in uniform areas having a density around 0.4 to 0.5 which in turn are printed from densities around 1.0 in the negative.

It was found that the graininess changed proportionately in the case of all the various densities so that in future tests it would prob-

ably only be necessary to work with a single uniform density around 0.4 to 0.5.

MR. HUBBARD: With regard to graininess, the second formula in Table II seems to be better. Why don't you recommend that?

DR. CARLTON: If you hold the concentration of sulfite constant and decrease the alkalinity by using a high concentration of boric acid and a low borax concentration you cut down the rate of development. This permits the sulfite to exert more solvent action and the graininess is therefore reduced. However, there is a tendency for greater sludge formation and the developer deteriorates more rapidly. A compromise has to be made.

MR. HUBBARD: The life of the developer would be short?

DR. CARLTON: Yes.

MR. BRIEFER: Can you indicate on chart No. 2 two negatives with equal gammas but with different degrees of graininess?

DR. CARLTON: All of the graininess measurements were made at the same positive and negative gammas so that you can take any one of them from poor to very good and you get a difference in graininess for the same gamma.

MR. CRABTREE: With regard to giving graininess measurements in terms of the size of the grain clumps, many such measurements have been made in our Laboratory but we are not convinced that all the factors entering into a measurement of what we see on the screen can be expressed mathematically. We are not convinced that we can express the boiling effect of graininess numerically. We think we can get more representative data by getting the reaction of a number of observers to what they see on the screen. It is dependent on the size of the grain clumps and the extent to which they move about.

MR. LAMBERT: Approximately, what are the relative magnitudes of graininess for "very poor" and "very good?"

DR. CARLTON: Graininess can only be defined in arbitrary units. The results reported here as "very good" if projected on an 8 foot screen and viewed from your position would appear homogeneous but those which are reported "poor" would show a distinct boiling.

MR. CRABTREE: We have evaluated graininess in terms of the distance from the screen, and for a screen 8 feet in diameter and measuring the distance at which non-homogeneity in the image is detectable the range varies from 10 to 25 feet.

MR. CLARK: With regard to graininess, the Bureau of Standards have a resolution factor determined by several dimensions, and I think the Society in dealing with such a subject should use terms adopted by the Bureau of Standards if they want standardization. They have tested the speeds of various emulsions; they have factors for that. In this way you know what exposure to give any film or plate. The Bureau of Standards have a very comprehensive paper on this subject, and I think the members should get it. It doesn't cost anything.

MR. CRABTREE: I am sorry to have to repeat that we don't know yet how to express graininess in strict mathematical terminology. Resolution doesn't cover the matter of graininess—it is merely related to graininess. You can measure the average size of the clumps of grains which you see on the screen but a mathematical measurement of the extent of their movement is difficult to obtain. Also you can have a type of graininess in which the clumps are almost invisible but there is a waviness on the screen which is what we call "secondary graininess." I don't know how this can be expressed mathematically.

MR. BRIEFER: Going back to the study of sulfite in the developer and its effect on the size of the grains. Some time ago we had a discussion on this, and this paper admits that there is a solvent action of the sulfite on the silver grains. That is, we are dissolving away part of the silver grain while it is developing. If we do this, we don't have as much silver halide left and you are asking us to accept the proposal that with different types of developers the grain size is smaller for the same density and the same gamma; that is, two equal densities developed with different developers have different grain sizes, and that is what I would like explained.

DR. CARLTON: With regard to the solvent action of the sulfite, the total amount of silver halide dissolved away is relatively small. If you were to dissolve one-quarter of the silver halide you would decrease the speed of the emulsion so much that it would be of no value for taking pictures.

Your misgivings about the difficulty of securing the necessary density after the sulfite has dissolved away some of the grains would be justified if we were developing to gamma infinity. In practice we are concerned only with negative gammas ranging from 0.7 to 0.9 under which conditions we are only using a fraction of the total density-giving power of the emulsion.

Mr. Briefer: It would be valuable if you added to this paper data showing densities against relative grain size for different types of developers. You need only one more curve in the tabulation instead of asking us to accept the statement that the graininess changes were parallel in the case of all the densities.

Dr. Carlton: We didn't think it was necessary.

BORAX DEVELOPER CHARACTERISTICS

H. W. Moyse*
D. R. White*

THIS study of borax developers was undertaken because their wide use emphasized the importance of detailed knowledge of their action. The results of the study not only permit the selection of a developer formula which seems very satisfactory, but also points out the sort of variations that will either increase or decrease the activity of the developer, to meet any special needs that may occur.

The tests were made with a number of negative materials in each development. Strips of films were exposed back of a sector wheel which gave a series of exposures, varying on a time scale with a factor of two steps between successive areas of the strip. The strips were then developed for a number of lengths of time in the developer being tested. During this development the flat developing tray used, was rocked systematically to give high, reproducible agitation which, rapidly removed development products from the emulsion surfaces of the strips which were held flat at the bottom of the tray. The densities were read as diffused densities and gave the density-time of exposure—time of development data used in comparing the developers.

To cover systematically the range of possible combinations of chemicals, two series of tests were conducted. In each series, one basic formula was being considered, and the tests centered to some extent on that formula; but in both series, the variations covered a relatively wide range of concentrations. Many of these, of course, were such that they could hardly be of commercial value, but they

Table I

Chemical	*Series 1*	*Series 2*	*Range*
Sodium Sulfite (Anhyd.)	100 g.	75 g.	1—200 g.
Borax	2	5	0—Saturation
Metol	2	2.5	0—10
Hydroquinone	5	0	0—20
Potassium Bromide	0	0	0—2.5
Water to	1 liter	1 liter	

* Redpath Laboratory, Du Pont-Pathé Film Mfg. Corp., Parlin, N. J.

all aided in showing the relationships among them and the developing effects of the constituents. Table 1 gives the two basic formulas and also indicates the range of concentrations tested.

Results

Sulfite

It was found that an increased rate of development accompanied increases in sulfite content up to a rather definite maximum, beyond which additional sulfite caused a falling off in high densities and in many cases a distinct loss in effective emulsion speed. Fig. 1 shows curves for one time of development in developers differing only in sulfite content.

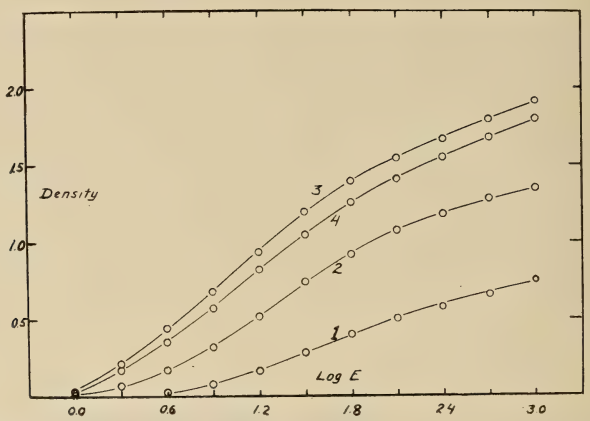

Figure 1. Eight minute developments with: Sodium sulfite, varied; metol, 2 g/l. hydroquinone, 5 g/l; borax, 2 g/l. Emul. No. 1612.

Curve No.	*Sulfite*	*Fog*
1	1 (approx)	.01
2	10	.06
3	50	.13
4	100	.14

The increasing development occasioned by increase of sulfite concentration from the initial low value is apparently due to the increased alkalinity produced by the larger quantities of sulfite. The alkalinity increases to a limiting value such that further sulfite additions leave it unchanged.

An increasing solvent action also accompanies increase of sulfite concentration. This solvent action has been known for many years and C. E. K. Mees and C. W. Piper published data on the quantities

of silver bromide necessary to saturate aqueous solutions of sodium sulfite. Under developing conditions, saturation may not be reached, and the rapidity of solution may be affected by the other chemicals present. To test this solvent action in developers, test series were mixed differing only in sulfite content. Equal quantities of film were developed for equal times in each developer and the silver content of the used developer was determined. Fig. 2 shows the change of

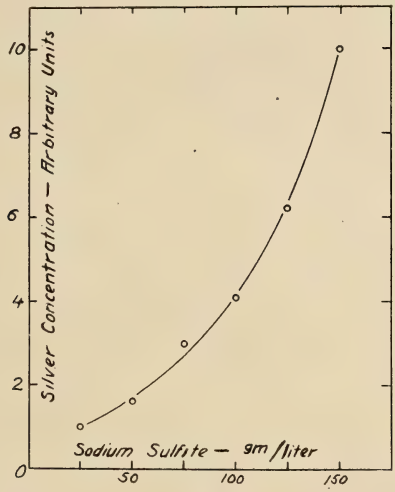

FIGURE 2. Relative silver content of developers after eight minute agitated development with the equivalent of 32 ft. of film per liter. The developing formula was sodium sulfite, varied; metol, 2.5 g/l; borax, 5 g/l.

silver content with increase of sulfite concentration. The slope of this curve is increasing rapidly, showing that a markedly greater effect of the solvent action is to be expected at the higher sulfite concentrations. The actual amount of silver observed in the developer was only a small proportion of the silver on the film, so small in fact that we hope to test more fully this solvent action to see if it really is a sufficient cause for the decrease of density observed.

The two effects just cited appear to be sufficient to account for the maximum development produced with increasing sulfite concentration. At low concentrations the increased alkalinity appears to be predominant while at high concentrations the solvent action seems more important.

Other workers have shown that high sulfite concentration tends to produce fine grained images. From a practical point of view, a

developer which gives a satisfactorily fine grain with maximum effective emulsion speed is to be desired. A sulfite concentration of 75 grams per liter was found to give satisfactorily grain free images, and at the same time to give a high effective emulsion speed.

Borax

The borax appears to influence the development only through its effect on the alkalinity of the solution, and hence, its effect can be completely presented only in conjunction with other factors affecting the alkalinity of the developer. For the simple case, varying borax only, Fig. 3 shows the effect on the development for the 8

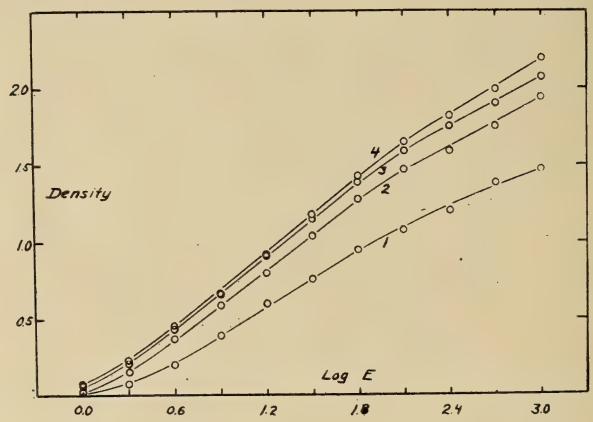

FIGURE 3. Eight minute developments with: Sodium sulfite, 75 g/l; metol, 2.5 g/l; borax, varied. Emul. 2568.

Curve	*Borax*	*pH*	*Fog*
1	0	8.7	.03
2	2.5	8.7	.07
3	5	9.0	.07
4	10	9.1	.06

minute period chosen. Increasing the borax increases the alkalinity (represented by increasing pH) with a resultant increase in the activity of the developer. With the quantity of metol used in this series, there is little difference between development with 5 and 10 gm/l. of borax.

Reducers

In the first series of tests with its low borax concentration it soon became evident that the hydroquinone did little of the development. When the basic formula indicated for this series was mixed

with the omission of metol, 16 minutes agitated development gave a barely perceptible density at the longest exposure given the test strip. Needless to say, such development is worthless. Mixing again, this time including the metol but omitting the hydroquinone, produced a fairly satisfactory developer, one which produced densities which differed but very slightly from those produced by the complete formula.

In the case of the second series a similar test was made, the results of which are presented in Fig. 4. Here the borax concen-

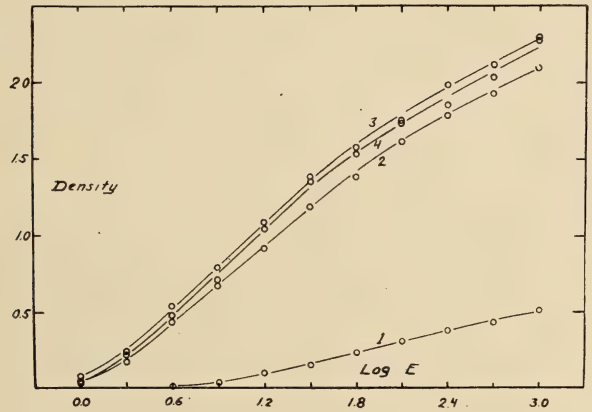

FIGURE 4. Eight minute developments with: Sodium sulfite, 75 g/l; metol, varied; borax, 5 g/l; hydroquinone, varied. Emul. 2568.

Curve No.	*Metol*	*Hydroquinone*	*Fog*
1	0	20	.07
2	2.5	0	.07
3	2.5	5	.08
4	2.5	10	.10

tration is higher than in the previous case and the hydroquinone alone does develop noticeably, but still not enough to make a worthwhile developer by itself. Metol alone is very satisfactory and the densities differ but little from those produced with an additional 5 or 10 gm. hydroquinone. The tests showed a tendency for fog to increase more than in proportion to the additional development produced by the increase of hydroquinone. The net result was that cleaner, more satisfactory development was obtained by increasing the time some twenty per cent with metol only as a reducer. The degree of increase of fog with hydroquinone differed somewhat between different emulsions, and in many cases was serious.

With metol alone as a reducer, the image density for fixed time of development does not increase indefinitely. Fig. 5 shows a series of curves with increasing metol concentration. It is to be noted that the alkalinity of the developer, pH, decreases due to the addition of the metol, which is sold commercially as a sulfate and hydrolyzes liberating acid in the developer, making the solution less alkaline.

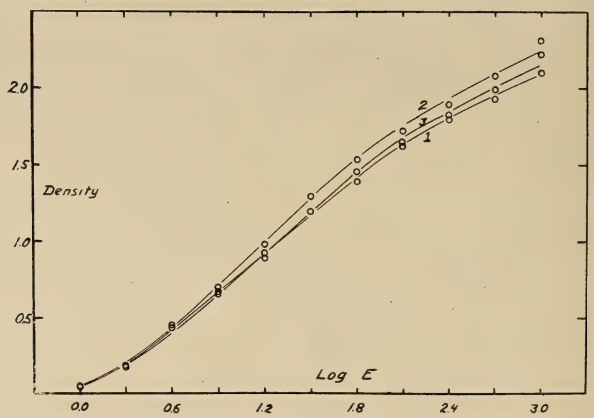

FIGURE 5. Eight minute developments with: Sodium sulfiite, 75 g/l; metol, varied; borax, 5 g/l. Emul. 2568.

Curve No.	*Metol*	*pH*	*Fog*
1	2.5	9.0	.07
2	5	8.6	.05
3	10	8.2	.07

The activity is thus so reduced that 10 g/l. of metol gives less development than 5 g/l. The increased concentration can be made more effective by progressively increasing the borax content as the metol is added, if that increased activity is desired. A balance of 5 g/l. borax and 2.5 g/l. metol together with 75 g/l. of sulfite gives a developer which very closely approximates the development rate of other borax formulas in use, and at the same time makes economical use of the expensive reducing agent.

Potassium Bromide

The fog produced by this developer is sufficiently low so that no bromide is needed as a restrainer. The retarding effect of bromide is shown in Fig. 6. Even with small quantities there is a marked loss of effective emulsion speed.

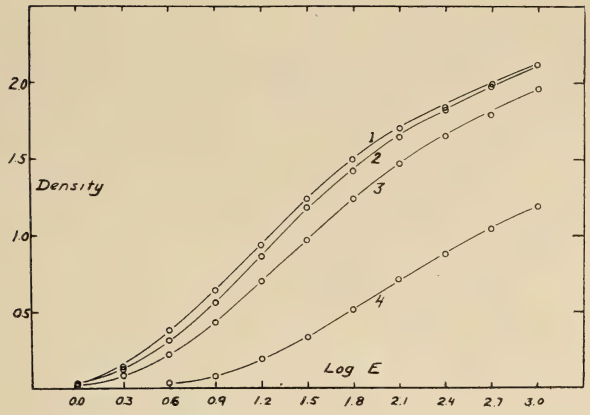

FIGURE 6. Eight minute developments with: Sodium sulfite, 75 g/l; metol, 2.5 g/l; borax, 5 g/l; potassium bromide, varied. Emulsion. 1612.

Curve No.	*Bromide*	*Fog*
1	0	.15
2	0.1	.12
3	0.5	.08
4	2.5	.04

The accumulation of bromide and other developer reaction products does not rapidly impair the development characteristics. Fig. 7 shows the results of an exhaustion test with this developer. It will

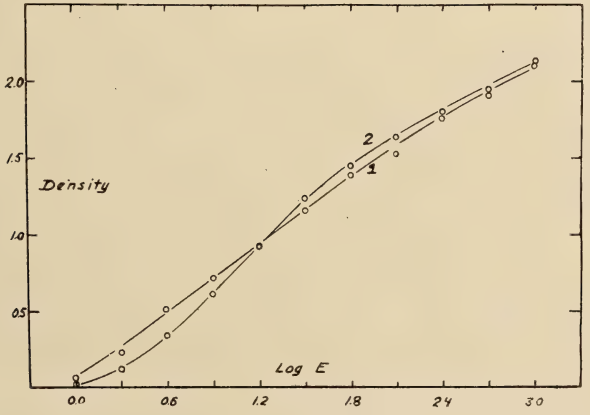

FIGURE 7. Exhaustion test of the developer recommended.

Curve No.	*Feet per Gal.*	*Time of Development of Test Strips.*
1	0	8 min.
2	400	12 min.

be noted that after 400 ft. per gallon had been developed, 12 min. in the old developer and 8 min. in the fresh developer produced a density of approximately 1 for equal exposures. This longer development, however, gives pictures with slightly less shadow detail than the shorter development time gives in fresh developer. The alkalinity of the developer under observation remained practically constant, showing that the necessary increase in developing time comes as a result of the reduction of concentration of reducer and the accumulation of bromide and reaction products in the developer rather than to alkalinity decrease. The practice of renewing a borax developing bath with additions of borax serves to bring the rate of development back to the original figure but cannot bring the detail giving power which has been lost through the progressive bromide accumulations. The permissible tolerance will vary somewhat with the class of work, and will determine the "life" of the developer.

DISCUSSION

Dr. Aster: Has the speaker collected data on the subject of addition of sensitizing dyes to the developer for cutting fog? Luppo-Cramer and others in Europe have reported on that subject. There was a recent article in the "Zeitschrift für Photographie" on this subject.

Mr. Moyse: We have approached that subject only in a qualitative way. In a recent test, Pinakryptol Green was added in various concentrations, but there was no decrease in fog; so we did not think it worthwhile to carry on.

Mr. Crabtree: You will find a very exhaustive paper in the Transactions by Dr. Dundon and myself on this. The effect of the oxidation product of a developing agent is that it acts as a desensitizer and reduces aerial fog. In the case of the borax developer which has a high concentration of sulfite, the aerial fog is practically the same as the chemical fog, so that I don't think there is any advantage to be gained by adding desensitizer to the borax developer in order to lower the fog.

DRY CELL BATTERIES FOR RECORDING AND PROJECTING

W. B. Schulte*

FROM inquiries received from sound-picture engineers and sound studios, we know that dry cell batteries are being used to a certain extent in recording and projecting. The details of why and how these batteries are used are not always available, probably, because the art is still experimental and perhaps also because some of the methods are being held secret. At any rate the interest in dry batteries indicates that they are becoming a standard part of the equipment. This being the case, a few words concerning dry cell batteries and their characteristics might be of interest to the motion picture engineers.

A dry cell battery is an electro-chemical unit which produces electrical energy from chemical reactions that take place within itself. It cannot be recharged similarly to a storage battery. A dry cell consists of a zinc container into which is packed a carbon rod surrounded by an oxygen carrying compound, a manganese dioxide ore, called a depolarizer. This depolarizer tends to maintain the current at a maximum value and aids the cell to recuperate and quickly recover its normal condition after periods of work. The open circuit voltage of a dry cell is about 1½ volts, irrespective of its size. The momentary current that a dry cell can fill depends upon its resistance, and ranges from 5 ampere for this very small cell, the size of a thumb, to as much as 50 amperes for the large 2½ inch by 6 inch size which is used on door bells, or as the Radio "A" battery.

The electrical capacity of a cell is more than proportional to its size. The larger the cell the greater the ampere-hour capacity; likewise, the cost increases with size, but not at as rapid a rate. Where high voltages are necessary a number of cells are soldered together in series to produce the required value. If large cells are used the bulk will be great, and the electrical capacity and cost high. With smaller cells the same voltage can be obtained in a smaller volume but with a lower electrical capacity and smaller cost. It is

* Burgess Battery Co., New York, N.Y.

impossible to establish any rule by which battery size can be determined, as there are so many factors that affect the choice. For example, the space or weight limitations, the current necessary and the cost of installation.

This discussion will attempt to touch on some of these matters; and from the experience of the dry cell manufacturers, call attention to those factors that the motion picture engineers should consider in choosing a dry cell battery for their unit.

General Characteristics

The characteristics of dry cell batteries, most generally discussed, are capacity, shelf-life, and recuperation.

Capacity is the electrical energy that can be obtained from the cells or battery. It can be measured as service hours or ampere hours when discharged under standard conditions to a definite voltage. In comparing two batteries, therefore, one must be sure that all of the test conditions are standard or at least comparable. For every size of dry cell there is a value of current where its capacity is the greatest.

Shelf-life is that quality of a dry cell which permits it to stand on a shelf for a long time without losing an appreciable quantity of its electrical capacity. In general a large cell has a better shelf-life than a small one, but it is much affected by the purity of materials and the methods of manufacture.

Recuperation is the measure of the ability which the cell has to return to its previous state of activity during an interval of rest following a period of work. As a cell is discharged, its working voltage gradually lowers. Periods of rest allow this voltage to regain a large portion of the previous value. Naturally a good recuperation is desired in a dry cell battery.

Testing

The only way by which the capacity of a battery can be measured is to discharge it. This of course ruins the battery for further use. Voltage and amperage measurements can be made on a battery, but they must be interpreted and weighed against the values obtained from similar batteries of the same manufacture.

Six inch dry cells, when sold over the counter, are usually flashed on a pocket ammeter which merely indicates that the cell

has or has not a low resistance. The short circuit flash of a cell is no true measure of its available capacity. To a buyer, or an engineer who is using the same batteries every day, the flash may indicate a variation from an average.

The voltage test is a reliable, practical test that can be made, but it likewise must be used with discretion. To rate a battery by voltage, it is necessary to know the number of cells that are contained in it so that the engineer can determine how closely the battery tests to the usual 1½ volts per cell.

Unless high resistance voltmeters are used, there will be a variation in indicated voltage between batteries of different sized cells, which usually shows the large and low resistance cells as having a higher voltage.

In an installation of two or more batteries, it would always be worthwhile to make a voltage test on each battery at the time of installation and record these data. At frequent intervals, other voltage measurements should be made with the same voltmeter and the voltage recorded. By keeping records of each battery in this manner the engineer or operator can easily tell if his batteries are falling uniformly. If there is a non-uniformity of voltage drop with respect to time, it will indicate that certain of the batteries are below average and should probably be replaced before the others.

The cut-off voltage of course is determined by the characteristics of the operating circuit, and the operator can determine this for his own information by making a measurement of it when the batteries are being replaced. The open circuit voltage of the batteries, when they are replaced, might be noted, and on subsequent battery installation this figure will be of a help in determining the condition of the batteries. It is impossible to say what the open circuit voltage of a usable battery will be, but it is generally higher than 1¼ volts. In other words, the open circuit voltage range of a "B" battery, between the time it is installed and when it is discarded, is only from 1½ to 1¼ volts.

Cut-off Voltages

When a cell is discharged, the working voltage drops rapidly at first. Then it slows down to a constant rate, but as the end is reached, it again drops rapidly. In comparing the capacities of

cells it is very important that the cut-off voltages be defined. Otherwise, the capacity comparisons are not equitable.

Apparatus that uses dry cells should be designed to operate on as wide a range of voltage as is possible. The greatest battery efficiency is obtainable when the cut-off voltage is low, and for this reason, the greatest battery economy is possible at a low cut-off voltage. For example, if a 45 volt battery is used on equipment that becomes inoperative as the battery drops to 40 volts, its service life might be 75 hours. If the equipment can be changed to work at only ten per cent lower voltage or 35 volts, the batteries will deliver 260 hours of service or an increase of almost 250 per cent.

Mechanical Handling

If dry cell batteries are used in portable equipment or in places where they are suspended or held by straps, certain suggestions can be made concerning the installation.

Dry cell batteries are an assembly of units in an insulating container, and these containers are subject to size variation. For this reason they are not always of the exact shape or size, and allowance must be made for these discrepancies. Too often, equipment is designed around a battery that is not standard, and later, much trouble results in trying to get batteries that will fit into the places allowed for them. Any battery manufacturer can give engineers the specifications of sizes for standard batteries which will usually accomodate those of other manufacture.

Batteries must not be strapped into position under excessive pressure. While they appear to be solid and substantial, a continual pressure might in time crack the sealing wax or break an electrical connection inside of the battery. Metal straps with sponge rubber cushions make satisfactory holding means for batteries.

Sometimes a bank of batteries is desired in a movable equipment. If possible, this should be so designed that the batteries can be assembled, fastened and electrically connected in a non-conducting container, which in turn is placed in the movable equipment. By having the batteries in a replacable container of this kind they can be taken into the laboratory and tested with proper instruments. Furthermore, a spare container with batteries can be assembled at leisure and quickly exchanged for one that has been in use.

Temperature

High temperatures result in a drying out of the chemicals in a battery and therefore decreases its shelf life. The energy obtainable from a battery is greater if the battery is kept warm because its resistance decreases. Experience shows, however, that batteries should not be stored or used at temperatures much above usual room temperature. If the projection booth is normally very warm, the shelf life of the batteries in it will be shortened.

The cold increases the resistance of batteries and lowers the flash. Dry cell batteries have been used in Arctic and Antarctic conditions where they were insulated by heat insulators and found to work satisfactorily. Unless the current drain from them is high, the normal cold temperatures that would be experienced in sound projection should have no influence on them. If dry cell batteries are used in motor trucks, and should stand at freezing temperatures for several days at a stretch, it is expected that they would not operate as efficiently as if the trucks were housed in a warm garage during rest periods.

Insulation

Because of the high voltages that are sometimes used, dry cell batteries should be mounted in insulated cabinets. This will prevent set currents from flowing through the containers of the batteries and producing voltage fluctuations and perhaps noise. Batteries should be spaced with air insulation between them whenever possible, and if not in an insulated cabinet, they should be mounted on strips of paraffined cardboard or wood to allow some circulation of air around them. Moisture or steam should be avoided. Where they are used out of doors and subject to temperature changes, the connections should be made so that if there is any precipitation of moisture on the surface of the batteries, it will not cause a circuit between terminals.

High Voltage Batteries

Eight or ten years ago attempts were made to use high voltage batteries on the "B" circuit of broadcast receivers. They were not successful, with the result that radio engineers standardized on a 45 volt unit which contained thirty dry cells. Receivers and vacuum tubes were designed to use these batteries or multiples thereof, such as 90 or 135 volts.

Photo-electric cells require higher voltages and photo engineers began combining units of 45 volt "B" batteries to supply their high voltage cells. As the currents that these cells draw are small, the smallest "B" batteries could be used. Battery makers thought they had gained enough information during the past years to enable them to assemble a satisfactory higher voltage unit of small dry cells. This was done, but it was felt that there was a danger in calling such a high voltage battery a "B" battery, and they were therefore termed "Potential" or "PL" batteries. These batteries, as they contain the smallest sizes of dry cells, should be considered as being a source of potential rather than as a generator of current. In exceptional cases, medium currents can be drawn from them, but it should always be under 5 mils.

These batteries have been used in a number of places in the moving picture field, because perhaps of their comparatively light weight and convenience.

The cells are cylindrical cells that have been double tested after aging. They are assembled in tubes of insulating paper and soldered together in series. To minimize current losses between adjacent cells, the connections are made to give the smallest voltage between them and a spacing of air insulation. As long as the batteries are kept dry and there is no moisture in them at the start, the air spacings between sticks gives the best possible electrical insulation.

These single unit, high potential batteries are convenient for use in portable amplifier units, especially with condenser microphones. For portable recorders, where compactness and a minimum of electrical connections are desired, they will supply the various high voltages.

In film sound projecting equipment, standard 45 volt large sized "B" batteries are being made use of, because the current drains are comparatively high. These batteries, furthermore, are easily obtainable at reasonable prices; as they are not moved after installation, there is not much danger from the many connections necessary to wire them into the circuits.

On truck recorders the battery requirements are varied. Potential batteries can be used provided the current drain is not too high. At present, the tendency has been toward the use of a number of 45 volt "B" battery units, but these have their objections because

the connections between them may work loose from the vibration of the truck.

Standardization of Sizes

Since 1921, the dry battery manufacturers, through the Department of Commerce, carried out a program of simplification and standardization of battery sizes. Practically all of the larger battery makers are acquainted with these standards, and they will be pleased to help motion picture engineers in their dry battery problems in the hope that whatever dry batteries are developed for this new art, will fit in with simple manufacture and a simple standardization.

If new batteries are needed, the battery manufactures will make them. They only ask an opportunity of being allowed to give their suggestions as to the best types that will supply the proper power at the least cost and with the least trouble of obtaining replacements.

DISCUSSION

Mr. Crabtree: If the battery is stored for two weeks at a low temperature (around zero Fahrenheit) are its properties permanently affected?

Mr. Schulte: At low temperatures the electrical resistance of a dry cell increases, but on being brought back to room temperature, the dry cell will return to its normal condition. This means that the short circuit amperage or flash of a battery will be low at low temperature.

Mr. Taylor: If you know that the battery is not to be used intermittently, so that the recuperation is not of interest, can it be designed differently, so that more will be obtained from it? How are the shelf-life and recuperation and the output? If you wish to favor one at the expense of the others, can anything be done this way with any real gain? Also, with reference to the high voltage batteries will they have a better shelf life than the standard battery, and, also, what voltages are standard or contemplated for the high voltage batteries? I have seen a 108 volt battery not in line with the units.

Mr. Schulte: If a battery is not to be used intermittently it is possible to change the composition of the mix so that it will give

more output than a present type of battery that is designed for an all-around service. However, the cost of putting in a new mix and making the battery nonstandard is more than would be justified from any possible market outlet at the present time. It is possible to favor one characteristic at the expense of others but the gain is very often too costly, either in quality or in actual cost in the manufacture. The high voltage batteries will not have a better shelf-life than the standard batteries. The voltages that are made will depend upon what the industry will require. At present they run 108 and 144 volts.

DR. ROSENBERGER: I should like to know the average shelf-life of a B-battery of 45 volts.

MR. SCHULTE: The average shelf-life of a "B" battery of 45 volts, is from six months for the two smaller sizes to a year and a year and one-half for the larger sizes.

MR. ROSS: Is the shelf-life also proportional to the humidity in the air and the temperature of storage, and is it possible to revive a large capacity battery (I am referring to a single cell such as the house cell) by drilling through the seal at the top and adding a solution. If so, what should the solution be?

MR. SCHULTE: High humidity and high temperatures decrease the shelf-life of a battery but I have not seen any data that would indicate that it was directly proportional.

It is possible to decrease the resistance of a used battery and obtain a fractional part of additional energy by adding an electrolyte to the battery. The energy obtained however is very small and there is no recharging effect. It is merely a wetting on the inside and a consequent decreasing of resistance. A possible liquid would be similar to the battery electrolyte which is a salammoniac solution.

A STANDARD MICRO-CINEMATOGRAPHIC APPARATUS

Heinz Rosenberger*

MOTION pictures have been used frequently in science and education. Their greatest value for scientific investigations lies in their domination of time. Very rapid movements photographed with the slow motion camera, and very slow movements taken with the time lapse camera are translated into perceptible speeds.

Another point in favor of motion pictures as applied to science is their usefulness for the study and demonstration of *microscopical* phenomena.

Except for a few attachments to be used by amateur photographers for their cameras, there has been, up to the present, no micro-cinema equipment available for scientific purposes. Attempts have been made by microscope manufacturers abroad to construct micro-cinema apparatus suitable for laboratories, but the results have not been encouraging. The designers of these apparatuses had erroneous basic ideas, for they had little or no conception of the requirements of research work.

The constant demand for a micro-cinema machine which would meet the requirements of research work and the production of educational films, brought the author, a microscopist as well as a trained engineer, to the study of what such a machine must accomplish. Apparatus devised by the author have been used in the production of the films of Dr. Alexis Carrel on living cells and of the late Dr. Hideyo Noguchi on Leishmanias and Trypanosomas.

Figure 1 represents the latest model of a complete micro-cinema apparatus which is the result of many years of experience. This machine has the especial advantage of being practical, efficient, and within the means of the average laboratory.

The instrument consists of four parts: (1) the optical bench with microscope and light source; (2) the camera table and stand with driving and timing mechanisms, exposure counter, and revolv-

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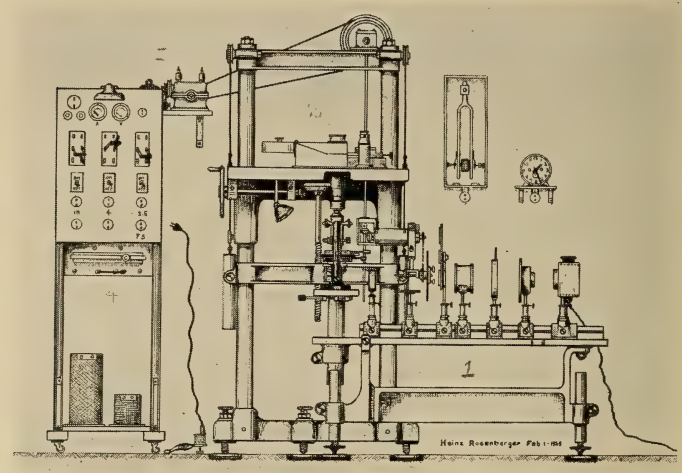
ing shutter; (3) the motor and reduction gears; and (4) the panel for the various electrical connections.

The optical bench is rigidly constructed of cast iron as a separate unit, and hence is vibration-free. The height can be adjusted and the bench brought to level by means of leveling screws under



A Standard Micro-Cinematographic Apparatus.

each leg which rests on a vibration absorber. The microscope, which rests on a table whose height is adjustable, can be moved either sideways or back and forth by means of screws. An incubator may be slipped over the microscope when a subject, such as tissue cultures, to be photographed has to be kept at a temperature above normal.

The camera unit is composed of two parts: the stand and the camera platform. The stand has a T-shaped, cast iron foot with a leveling screw, resting on a vibration absorber, at each one of its three extremities, two vertical steel rods, and a cross bar. The platform may be moved the entire length of the two vertical steel rods by means of a hand pulley or simply by sliding.

Synchronously connected with the camera is a revolving shutter which provides intermittent illumination when high frequencies are used. For low frequencies, an electric timer starts or stops the motor and turns the light on or off. The timer is governed by an electric clock which closes a circuit at predetermined intervals. This

is accomplished by means of a relay which starts the driving motor. When the camera drive has completed one revolution, one exposure has been made, the machine stops automatically, and is ready for a new impulse from the clock. The length of exposure is regulated by an adjusting screw.

The motion picture camera is mounted on a slide so that it can be moved from side to side to align the tube of focus control with the optical axis of the microscope.

In order to exclude transmission of vibration, no mechanical connection exists between the microscope and the camera; a telescope tube hanging into a collar attached to the microscope eliminates the outside light and allows the projected light to come on to the film. Instead of the telescope tube an observation tube or a bellows slipped in from the front part of the camera platform, may be used.

If *macroscopic* pictures are to be taken a photographic lens is screwed into the face plate of the bellows and the microscope is removed. The adjustable microscope table can then be used to hold the objects to be photographed. With this arrangement, the apparatus is employed for ordinary vertical cinematography (for objects immersed in water, small animals, or animated drawings).

In order to photograph phenomena which have to be taken horizontally, for example, objects in aquariums and slow chemical reactions in test tubes, a 45 degree mirror is attached to the photographic lens.

Film records can therefore be taken without using the optical bench with the microscope.

The motor is connected by a leather belt, directly for high frequencies, or indirectly, by means of reduction gears for low frequencies including stop motion.

The distributing panel supports rheostats for the motor, for low and high intensity arc lamps, connections for foot switch and light increaser, and several additional plug receptacles. Casters under the panel permit its being moved about so as to be close to the hand of the observer at all times.

LITERATURE

1. Alfred E. Cohn, J. Hamilton Crawford, and Heinz Rosenberger, Cinematography of skin capillaries in the living human subject, *Proceedings of the Society for Experimental Biology and Medicine*, 1924, xxii, 89.

2. Heinz Rosenberger, Der Kapillarograph, *Die Kinotechnik,* 1925, vii, 585.

3. J. Hamilton Crawford and Heinz Rosenberger, Studies on human capillaries, *The Journal of Clinical Investigation,* 1926, ii, 343-374.

4. Heinz Rosenberger, Micro motion pictures, *Scientific American,* March, 1927.

5. Heinz Rosenberger, Micro-cinema in medical research, *Transactions of the Society of Motion Picture Engineers,* 1927, xi, 750.

6. Heinz Rosenberger, Der Kapillarograph, *Mikrokosmos,* 1927-28, xxi, 120.

7. Heinz Rosenberger, Mikro-Kimematographie im Dienste medizinischer Forschung, *Die Kinotechnik,* 1928, x, 329.

DISCUSSION

MR. BARRELL: I don't want to embarrass you with any details, but could you tell me about the cost of these two installations?

DR. ROSENBERGER: I think the equipment as drawn in the previous slide costs about $2500 and the latter one about $1500.

MR. MALKAMES: Have you any means for focusing while photographing?

DR. ROSENBERGER: Yes, there are two means: the first is looking at the back of the film and observing the picture through the camera. The special camera, shown in the first slide is but 90 mm. [about 3½"] high which is very convenient. The second way of focusing during the taking is through a so-called beam splitter, which is a cube consisting of two prisms one of which is slightly silvered, 95 per cent of the light goes through onto the film, while about 5 per cent is reflected into the tube and is of service for observation.

MR. MALKAMES: What would be the disadvantage of using the regular objective on the camera focused at infinity and also focusing the microscope at infinity?

DR. ROSENBERGER: This can be done, but I try to avoid as much glass as possible in the beam of light.

MR. MALKAMES: What would be the loss of light in such a system as the objective on the lens?

DR. ROSENBERGER: The loss of light is negligible, but I think optical resolution is most important, and a great deal of resolving power is lost if there is too much glass in the beam of light.

PERMEABLE PROJECTION SCREENS FOR SOUND PICTURES

A. L. Raven*

IN THE development and growth of a great industry there is often an element or factor whose importance is at first overlooked, or if taken into account at all is considered of small relative value, but which later proves to be one of the real essentials.

In the motion picture industry, the projection screen was for a long time in this category, being looked upon figuratively as a step-child instead of receiving the attention it deserved as one of the most important adjuncts of the business.

In the early days of the motion picture, as is well known, anything in the form of a white sheet seemed to be satisfactory if it could be bought cheaply enough.

With the advent of the larger theatre, however, and the consequent increase in the size of the picture shown, it became evident that something must be done to utilize the light available at the projector to better advantage, and so began a series of more or less extensive experiments, the results of which were the various types of specular screens, embracing a wide range of materials and construction, such as frosted plate glass mirrors, various specular metallic paints spread on heavy muslin or duck, crushed crystals in several sizes and forms, and also layers of small glass beads partially embedded in white paint or other pigments spread on fabric.

These screens proved a boon because of the great increase in the amount of light reflected.

The fact that, due to their specular characteristics, they distributed this light satisfactorily over only a very narrow area, and the "high-lights" in the picture were inclined to be over brilliant and glary, was not at that time given much attention.

It soon became evident however, that the *quantity* of light reflected by a screen was of secondary importance, while the *quality*

* Raven Screen Corporation, New York, N. Y.

of the light, and the manner in which the screen distributed or reflected it to the audience, were of the utmost importance.

Extensive research and experiments finally resulted in the production of screens that leave little further to be desired in the way of detail; even distribution of reflected light, reduction of glare in the high-lights, elimination of eye strain and fatigue and uniformity of brilliancy over the entire screen surface, regardless of viewing angles.

In fact, the high grade diffused reflection type screen, now in use in many of the first class theatres, is so perfect and fulfills requirements so well that the audience is (as it should be) entirely unaware of the screen's presence.

As soon, however, as the screen reached this state of perfection and screen manufacturers generally, were beginning to feel that they had at least really accomplished something, the whole situation, as regards the screen, was changed over night by the introduction of sound or talking pictures.

Right here history repeated itself, and due to the fact that during the development of the sound devices no serious attention was given the matter, the industry once more found itself without a suitable screen and realized that a matter of major importance had been overlooked.

As soon as this was apparent, efforts were made to correct the fault, and there are now a number of screens on the market especially designed for talking pictures.

If the horns or loud speakers are to be placed behind the screen it naturally follows that the sound, to appear natural, must pass through the screen and, in doing so, should meet with as little resistance as possible in order that absorption and distortion will be reduced to a minimum.

The composition of the screen and the extent of its permeability are therefore matters of paramount importance when considering sound.

The material itself should be non-absorbant, but should contain as many unobstructed passages of as large area and little depth as can be incorporated in the structure, so that it will be permeable to the fullest extent.

In considering the screen from the picture standpoint, however, quite a different proposition confronts us. The composition

of the screen material, except as regards its face finish, is of no particular import, but any openings in the screen such as pores, or perforations, regardless of their size, having their axis normal to the screen surface, are detrimental to the picture.

How serious this detriment is depends upon their size, number and distribution of the pores or perforations. Therefore, a screen ideally constructed to meet the requirements of sound passage and picture reflection would be a veritable paradox.

"Sound Picture" projection has been greatly improved with the perforated screens now in general use for some systems of sound pictures; but it is still impossible to produce clear sharp pictures such as were being shown in the best theatres before the advent of the "talkies" however fine the film print may be or what amount of light may be used in the projector.

The lack of clearness, depth and detail and the presence of blurs and smudge in most of the sound pictures now being shown, are due to the pores or perforations in the screen, which, while not being individually discernable from a reasonable distance, nevertheless affect the picture as it would be affected if the screen were covered with small black spots equal in size and number to the pores or perforations.

When viewing a picture on such a screen the effect is much the same as when looking at people or objects through a dusty plate glass window.

Many exhibitors think that this lack of definition and the smudgy appearance are directly due to the loss of light through the pores and perforations and could be corrected by increasing the light in the projector sufficiently to compensate for the seepage through the screen.

In the author's opinion this impression is a fallacy.

The fact of the matter is that an increase in the projector light tends to emphasize and enlarge, rather than reduce the fault.

This will readily be understood if we realize that the perforation reflects no light at all while the screen material, adjoining the perforation does reflect light.

Increasing the amount of projected light would increase the amount of light reflected by the screen material but would not change conditions so far as the perforations are concerned; therefore, the

contrast between the two portions would be increased and the faults proportionally emphasized.

It can easily be shown that a screen will reflect a much better picture before being perforated than after it has been so treated, even though the perforated screen be given more than enough extra light to compensate for the light which passes through the perforations.

The great objection to increased amperage or light is the excessive damage to the film and also the extra fire hazard.

A method of screen construction has been evolved however, and is now being perfected, which will permit free passage of sound *through* the screen and yet inhibit the passage of light, so that there is not only an improvement in the sound effects but in the picture as well. In this construction there are no pores or perforations having axis normal to the screen surface, and consequently no light from the projector passes through the screen, unless, of course, it be projected from a severely oblique angle, and since there are no open spaces or passages discernable to the eye, it follows that the black spotted effect will not be present and consequently there will be no smudge or blurred effect in the screen, and the pictures will be equal in every respect to what they were before sound pictures and permeable screens were introduced.

The construction of this screen is such that the openings are oblique to the screen surface and is based on the well known fact that most sounds readily pass around objects and corners while light (except under certain conditions) will not turn corners; as it only travels in straight lines.

This method makes it possible to have unobstructed passage for sound equalling 45% to 80% of the screen area and yet retain a 100% opaque light reflecting surface.

Several methods of construction have been tried out, but the best results have been obtained by assembling very narrow strips of thin opaque light reflecting material somewhat in the form of a louver.

This gives the necessary depth to the sound openings to inhibit the passage of light and still permits the use of thin materials, so that the absorption or damping factor is kept at a minimum.

The directional effect, that such a construction might be expected to have on sound, has been found to be negligible if apparent at all.

The picture surface of this screen has a slightly corrugated effect, but this is not at all discernable at distances from which pictures would ordinarily be viewed by an audience. From such a distance it appears to be a regular opaque screen without perforations or openings of any kind, and the reflected picture has no suggestion of haze, smudge or halation and is perfect in depth and detail.

DISCUSSION

Mr. Ross: I suggest that the speaker use some chalk and the board to give an idea of the louvers.

Mr. Raven: There are so many things involved, and the structure of the screen is so intricate that I doubt being able to sketch it. (Drawing)

The veins lie somewhat in this manner, and it is possible to get from 45 to 80 per cent of open space, depending upon how close the veins are placed and the angle of their inclination.

These limits are governed mainly by the theatre in which the screen is to be installed. On a large screen, such as would be installed in a theatre like "Roxy's," it is possible to have considerable separation between the veins before the roughness, due to the separation, becomes noticeable to the audience, because even the people in the front rows sit at a considerable distance from the screen; but in the smaller theatres, where the audience is rather close to the screen it is necessary to reduce the separation, which, of course, cuts down the amount of open sound space. Fortunately, the smaller theatres do not require the same volume of sound as the larger ones, and advantage can be taken of this, and screens built suitable for any theatre.

The viewing angle of that part of the audience seated here (indicating the main floor of auditorium) is such that it is impossible to see through these openings. The people who are elevated sufficiently to be able to see through are in the rear of the balcony and generally so far away from the screen that detail is beyond their perception, and the possibility of their being able to detect the openings is remote.

THE ACADEMY OF MOTION PICTURE ARTS AND SCIENCES

FRANK WOODS*

IMPORTANT events have occurred in the history of the Academy's progress since the last information conveyed to your distinguished Society. These events may be summarized under the following heading:

1. Installation of sound equipment.
2. College Cultural course.
3. Bestowal of Merit Awards.
4. Stanford-Muybridge Memorial.

Through the courtesy of the Electrical Research Products, Inc., the Academy is now equipped with a complete sound reproducing system, said by the engineers to be the best on the Pacific Coast. In addition to reproducing sound by disc or film, the equipment may be used for the double film method by which the picture is on one film and the sound on another running synchronously.

The installation was inaugurated by a general meeting of the Academy on April 24, at which President J. E. Otterson of Electrical Research Products, Inc., was the guest of honor and principal speaker. At this meeting the plans of the Academy for the future use of the equipment were announced and discussed. There was general agreement in the thought that with this new installation the Academy is now in a position to be of more value to the industry than it has ever been before.

All of the Branches have announced series of meetings to demonstrate and discuss problems peculiar to each of the several classes—writers, directors, actors, and technicians. In addition to this use to which the new equipment will be devoted, the Academy has extended to representative committees from National Better Film organizations, the courtesy of the Academy quarters for previews of new pictures. These committees make reports to their national headquarters regarding the pictures they preview, and these reports are then distributed throughout the country by the organizations. It is in no sense a censorship, but rather a report to

* Hollywood, Calif.

the public for the purpose of encouraging improvement in quality and healthy entertainment values.

A cultural course on motion pictures at the University of Southern California, which has been inaugurated and supervised by the Academy, is now nearly completed. The following lectures have been delivered or are scheduled:

Introductory	J. A. Ball
Douglas Fairbanks	J. Stuart Blackton
Dr. Rufus Von KleinSmid	Frank Woods
Dr. Karl T. Waugh	Paul Bern
Scientific Foundations	Benjamin Glazer
Early History	Irving Thalberg
Later History	Clara Beranger
The Silent Photoplay	Conrad Nagel
The Photoplay with Sound	William Cameron Menzies
The Modern Photoplay	M. C. Levee
The Story	Edwin Schallert
The Actor	Dr. Karl T. Waugh
Pictorial Beauty	Dr. J. A. Leighton
Commercial Requirements	Control of the Screen
Principle of Criticism	Prof. Emery S. Bogardus
Social Utility	Future of the Photoplay
Photoplay and Aesthetic Culture	William C. deMille

It will be observed that the nature of this course is not technical and that it is meant only to create, or help create, a better understanding of the motion picture in its social aspects.

The Academy, through its Boards of Judges, bestowed fifteen first awards on those deemed entitled to recognition for distinctive achievements in motion pictures in 1928. The nature and significance of this action, which it is intended to make a yearly event, will be better appreciated by considering the list of awards which are as follows:

Emil Jannings, first award for his performances in "The Way of All Flesh" and "The Last Command."

Janet Gaynor, first award for her performances in "Seventh Heaven," "Sunrise" and "The Street Angel."

Frank Borzage, first award for directing the dramatic picture "Seventh Heaven."

Lewis Milestone, first award for directing the comedy picture "Two Arabian Knights."

Ben Hecht, first award for writing the original story "Underworld."

Benjamin Glazer, first award for adaptation of "Seventh Heaven."

Joseph Farnham, first award for title writing.

Charles Rosher and Karl Struss first awards for cinematography of "Sunrise."

William C. Menzies first award for art direction "The Tempest" and "The Dove."

Roy Pomeroy first award for engineering effects in "Wings."

Paramount-Famous-Lasky Corporation first award for production of the most outstanding picture—"Wings."

The Fox Company first award for production of most unique and artistic picture "Sunrise."

Special First Award to Warner Bros. for producing "The Jazz Singer," the pioneer outstanding talking picture.

Special First Award to Charles Chaplin for writing, acting, directing and producing "The Circus."

Besides these first awards twenty honorable mentions have been awarded.

The foregoing awards will be formally presented to the winners at the second anniversary dinner to be given by the Academy May 16, 1929.

The Academy was honored by an invitation from Dr. Ray Lyman Wilbur, President of Stanford University, now Secretary of the Interior, to participate in the University Ceremonials on May 8 commemorating the first photographing of horses in motion which was successfully accomplished through the efforts of Senator Stanford and Eadweard Muybridge fifty years ago.

The Academy's contributions to this memorable celebration are as follows: a delegation of prominent Academy members, including Louis B. Mayer, William de Mille, Conrad Nagel and others; a considerable quantity of interesting material for exhibition in the College Museum; a talking picture of the President of the University, recorded by the Fox Company and reproduced as a part

of the ceremonial program by means of new portable projection and sound reproduction equipment furnished by the Electrical Research Products, Inc.

One of the most important functions of the Academy has been that of maintaining harmonious relations between the different elements employed in making motion pictures. This work has been progressing in a very satisfactory manner, largely through the successful operation of the conciliation machinery of the Academy, whereby any differences or controversies that may arise between different individuals or companies in the business may be settled by harmonious agreement.

Among the projects being considered for the future, mention may be made of a proposed book to be published by the Academy in advisement with the University of Southern California and other similar institutions. It is too soon to give an outline of this book, but it will have as a basis the lectures delivered in the cultural course at the University of Southern California, all to be edited or rewritten for publication purposes. To these lectures will be added additional papers rounding out the entire subject so that when the book is finally completed it would be an "Outline of Motion Pictures."

In conclusion permit me to say that the Academy's best wishes are extended to the Society of Motion Picture Engineers with all possible co-operation in matters of common interest.

PHOTOGRAPHIC ASTRONOMY

LESLIE E. CUFFE*

IN PRESENTING this paper, I wish you all to thoroughly understand that I am not an Astronomer; in fact, I had never given Astronomy much thought until a Charles F. McManus came to me with several pages of data he had secured, dealing very technically with Astronomy, and asked me to read them over and let him know if there were any possible picture material in it. I started to read, but before very long I found myself millions of miles away from this little Earth of ours with very little chance of getting closer as I read further.

This struck me as being a great thing. Imagine in a few feet of film being able to take an audience out into space through great planets, star clouds, great gaseous regions, and into universes so great that this little earth and sun and few planets we see and feel about us become insignificant as compared to these enormous universes. With this thought in view, I took all this material and grouped it into what I knew would make four very interesting pictures, building around each group sufficient story and travel to make them also interesting to the non-technical mind.

The first picture I titled "Mount Wilson," and dealt more or less with the different telescopes, and their differences in magnification when compared in focusing on a given star, and a few random shots of the heavens, showing the great Globular Clusters and Cepheids— some of the most remote objects of the entire heavens. In the second picture, which is titled "Our Solar System," I dealt entirely with our sun and its eight planets, which are all in close proximity to our earth. However, these planets of ours, due to their closeness and the tremendous distance that we (our solar system) are from the rest of the universes, do not make any spectacular shots, due to the fact that when a telescope of such great magnitude is focused on such a close object, the objects in the regions behind and beyond these planets are so remote that the plain of focus does not pick them up. The third picture I titled "Our Universe." It deals with the closer Nebulous Clusters, or star clouds, that comprise "our

* Hollywood, Calif.

universe'' and are not as remote as the objects in the great galaxy. In the fourth and last grouping, which is titled ''The Galactic System,'' we take you out into universes, millions of light years from this earth of ours, and bring you close to these enormous universes whose light, traveling at the tremendous speed of six trillion miles per year, has taken over a million years to reach this small earth of ours. This we have captured and photographed and brought to the screen. It is one of the most incredible sights the human eye has ever witnessed.

I am now going to try and explain briefly some of the difficulties we encountered and overcame in the making of these pictures which you will see later.

There are many obstacles which present themselves that heretofore have not been encountered in the photographing of motion pictures. For example, when our camera was placed in the telescope, and the telescope focused on a given object, we immediately encountered, on time exposure, eight motions that had to be corrected, for the earth is constantly revolving on its axis and traveling along its orbit, while its poles are constantly tipping and revolving in the fashion of a top that is losing its speed and starting to slow down. At the same time the sun is traveling through space on its orbit, and the object which we are photographing is revolving and going through space on its orbit; therefore when all these motions are taken into consideration there is a constant changing and displacement of the earth in relation to any object in the heavens which we may be photographing. To offset all these motions that are encountered in relation to the earth and the various objects in the heavens, these enormous telescopes are all controlled electrically and by clockwork, so that over a given period of time the same position of any object can be maintained in the heavens, after the telescope is once set by the professor.

The next difficulty we ran into was the exposure necessary for the different planets, nebulae, star clouds, and universes we had to photograph. Each object had to be tested individually before the actual shooting of the camera to determine the time exposure necessary per frame of motion picture film; this alone took considerable time, when we take into consideration that our photographing time—exposure per frame on the nebulous clusters, illuminous gasses, dependant and independant groups of suns and their sur-

rounding worlds—took exposures from three hours and fifteen minutes, to four hours per frame; or we might say the average exposure was three and one-half hours per frame. The sun we photographed at normal exposure. The moon, which we photographed when full in order to get the maximum light volume, took seventeen minutes exposure per frame. The planets surrounding our sun varied directly in relation to their distance and the color of light being given off from them. For instance, Mars, which has a red glow, photographs fairly fast as compared to Uranus, which has a pale green glow. Mercury is one of the hardest of our planets to photograph, due to the fact that it lies in a path between us (the earth) and the sun, and the light from the sun can only be overcome at certain seasons and times. The other planets, except Neptune which has a pale blue glow, photograph fairly fast; however this color value of Neptune is offset by its tremendous distance from the earth.

It was necessary to use the hydrogen filter in all our photographing, as we found this was the only filter that would photograph through the gasses of atmosphere and water vapor which surrounds a lot of the objects we were photographing.

Our process of photographing the heavens which we have recorded (incidently they are the only authentic records on motion picture film of these different bodies) took over a period of fourteen months. We worked every night through the different telescopes on Mount Wilson, California.

The work was made possible only by the fine co-operation that was given us by the Carnegie Institute of Washington, D.C., and the untiring efforts of Dr. Adams, Professor Joy, and Professor Ellermen, of the Mount Wilson observatory staff.

In photographing the heavens, it was necessary to focus the object from the ground glass of the telescope through a wide angle lens in the camera, which necessitated incorporating the camera in the body of the base of this enormous telescope at that point where the eye piece prisms are attached for viewing. This meant that the camera had to be left in the telescope for many months. The only camera we could get into this small space was a Universal which served the purpose very well due to the fact that it was all stop-motion work.

Before looking at the pictures, I would like to draw your attention to the uneveness of rotation in some of the heavenly bodies. This is caused by the stop motion and long exposures; the change from one night to another in photographing time; and the continual movement of the object being photographed.

PHOTOGRAPHING WITH MULTIPLE CAMERAS

KARL STRUSS*

IN PHOTOGRAPHING dialogue or talking pictures, there are various methods in use, depending mostly on the type of story being filmed. In this article we will discuss only the method that was used in picturizing "Coquette," on which four cameras were used for most of the sequences. Previous to the actual photographing, two weeks were spent in rehearsals of all the characters having speaking parts, and at the last rehearsal, the camera positions were determined with the co-operation of the director, Sam Taylor.

The focal length of the lens that each camera was to use was arranged at that time, and notes were made of exactly what was required of each cameraman. The four cameramen were present at the final rehearsals and so were able to follow, with their finders, the complete action of the story as it progressed. The action was fairly continuous and the scenes ran an average of three or four hundred feet each. Whenever the locale or action called for a change, new camera set-ups were mapped out. In working out a line-up, the first camera considered was the long-shot camera, equipped with a lens of 35 mm. focal length, which obtained a record of the whole action from beginning to end, from the most advantageous position. The reason for using the 35 mm. lens instead of a 40 mm. or 50 mm. lens for the long shot, was to enable the other cameras, with the longer focal length lenses, to work closer to the characters, and thus we did not have to use lenses of say, six, eight and twelve inch focus, with their shallow depth of focus necessitating very accurate measurement of the distance to the characters. The other cameras using lenses of two, three and four inch focal lengths were then placed to get the best possible view of certain portions of the scene closer up.

All during "Coquette," the longest focal length lens used was the four inch, which at an average distance of about twelve feet gave a fair size close-up. Occasionally, there were times when closer silent shots were made, which expressed reactions to the dialogue. Each line-up required different combinations of lenses from vari-

* Hollywood, Calif.

ous positions, depending entirely on the action and the positions and number of characters in the scene. Sometimes, the cameramen changed their lenses from one focal length to another in the course of a scene, in order to adapt their set-up to some change in the grouping of the characters. These changes, of course, were always made at definite times in the action or on certain cues, while the full scene was being covered by some other camera. Each camera was placed so that when it was used, the best angle of the action was obtained, and the characters were lighted accordingly.

The advantages of photographing with more than two cameras at the same time are numerous. The actor's action can build up to a climax to much better advantage; the lighting can be arranged to cover the action for all the cameras; the photography can be more uniform and a more even negative secured; and the sound track, likewise, will be of better quality and of less variable tone. The scene as then photographed is a completed picture.

To facilitate and speed the actual photographing, the chief cinematographer on "Coquette" supervised the lighting for all the cameras; for, knowing the problems, set-ups, backgrounds and lenses of each camera, he could more quickly judge and decide what was to the best advantage of all, and he was not hampered by having to give his time to the detailed attention required in the manipulation of a camera. Having the chief cinematographer remain outside of the booths in this way is of considerable advantage to the director, as it enables him to have first hand and immediate information on any photographic problem that may arise from time to time.

The longest scene photographed in "Coquette" was the completed scene of the trial, which recorded the testimony of Miss Pickford. On this, six cameras were used. The actual footage was nine hundred and ninety feet for each camera, the duration of the scene taking eleven minutes. This was quite a test for all the actors to know their parts letter perfect, as well as for the cameras to follow the action without a false move, and it speaks well for the organization and co-operation every one gave. By being able to photograph all the action simultaneously with six cameras, and from six different viewpoints, it was possible to complete this scene, originally scheduled to take five days, in the short space of two days and without any rush.

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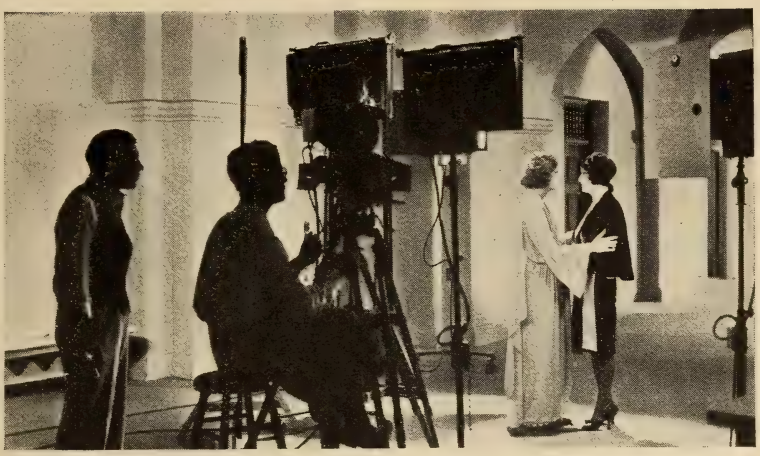

GRETA GARBO *and Dorothy Sebastian in a scene from "A Woman of Affairs," Clarence Brown directing. Courtesy of Metro-Goldwyn-Mayer*

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